COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XIII JANUARY, 1908 No. 1

AIR COMPRESSORS ON NEW YORK TUNNEL WORK

By Frank Richards.

The tunnel stage of the development of New York city may be said to have really commenced with the present century. Although the first tunnel under the North River was planned and begun a quarter of a century ago, it has only lately been completed with also its twin tunnel for the reciprocal traffic. On account of the earlier completion of connections, other tunnels begun within the present century will be in established service before these.

The tunnels completed or approaching completion, including the two mentioned above, are as follows:

Six tunnels under the North River; the two from Morton street, Manhattan, to Hoboken to be used for trolley car service; two near Cortlandt street and two about Thirty-third street for the Pennsylvania Railroad, and eight under the East River; two from the Battery up into the heart of Brooklyn, as a continuation of the already completed Subway; four to connect the Pennsylvania Railroad with the Long Island Railroad, two of these tunnels also extending all across Manhattan; and the two so-called Belmont tunnels which are

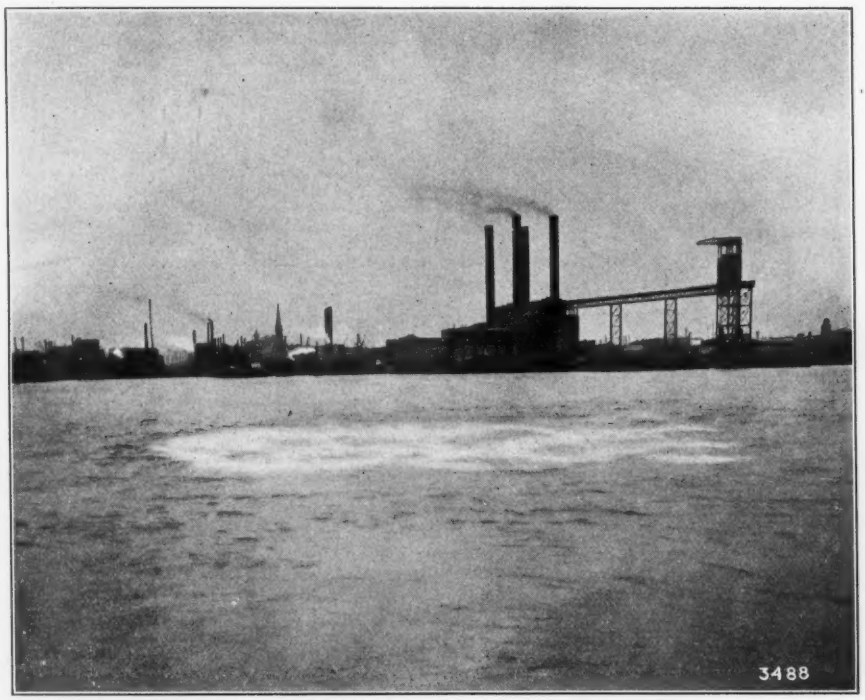


Fig. 12. Escape of Compressed Air from Tunnel Working.

to connect the Forty-second street line of the present Subway with Long Island trolley lines.

This tunnel work involves not only the actual driving of the tunnels under the rivers as indicated, but greater additional lengths of subterranean tunneling for the approaches or connections. Other tunnels "too numerous to mention" in these and other directions are planned and more or less specifically provided for to supply work for at least twenty years ahead, by which time the tunnel habit will have become so established that no one now can suggest the amount of subterranean and subaqueous excavation and construction which will ultimately be required in New York and vicinity.

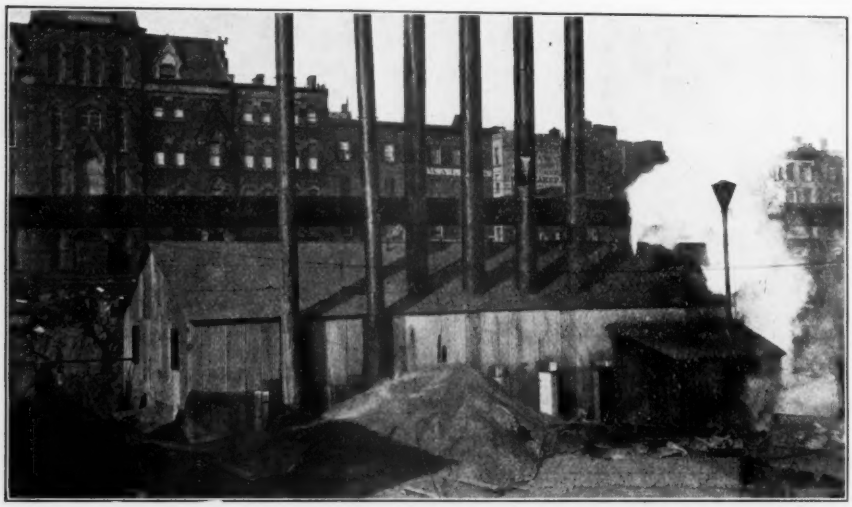


FIG. 1. TEMPORARY POWER HOUSE, PENNSYLVANIA TERMINAL.

We have here to do with only one, although the most important, physical agency in all this tunnel work, the compressed air supply. Merely to enumerate the air compressing plants which have been installed in New York for tunnel work alone, with mention of a few of their most important details, is enough for the present paper.

It will be noted that all the air compressors herein enumerated are New York machines, machines largely developed by New York practice in the building of the Aqueduct, supplemented by mine and tunnel work throughout the world, and perfected and manufactured by the two New York companies of world-wide reputation in this line, the Ingersoll-Sergeant and the Rand, now in the natural course of business events combined in a single concern, the Ingersoll-Rand Company. The position of this company in this great metropolitan

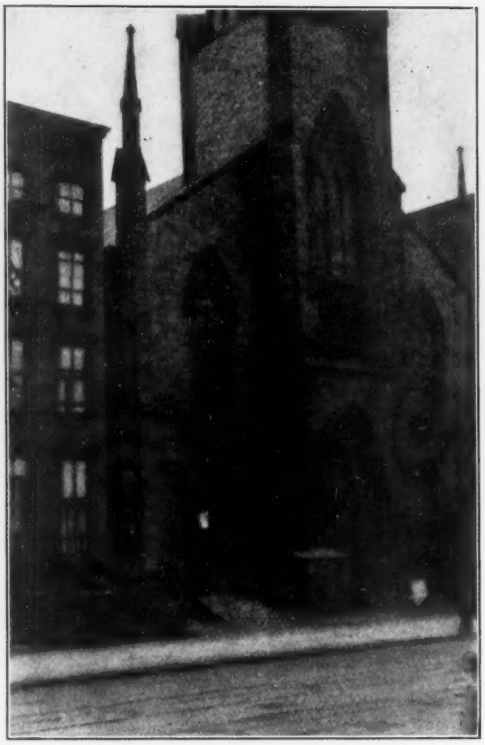


FIG. 2. POWER HOUSE, PENNSYLVANIA TERMINAL.

development is unique, and cannot be approached for parallel or comparison in any other line of business.

That there is plenty of tunnel work ahead for the air compressor might well be inferred from the substantial and apparently permanent character of many of the installations. Several of the plants here mentioned will undoubtedly be employed to supply the air for other tunnels besides those for which they have been originally erected. These plants accordingly have generally nothing cheap or temporary about them. They employ all the usual well-known devices of economy both in the use of steam and in the compression of the air. The boilers are all of modern design and nearly all of the water tube type. The steam units are usually compound and condensing, and the air compression two stage with intercoolers and aftercoolers. Gravity oiling systems are installed, which constantly and perfectly lubricate every part and return the oil for repeated use. The action of the compressors is regulated automatically according to the call for the air, so that a series of machines will run constantly without handling the throttle. Recording gages are generally employed and their records are watched and filed in the offices.

While as a rule nothing has been neglected in the installation of those plants which could contribute to the reliability and economy of their operation, to the accessibility of parts and convenience of manipulation, so that, seen within and with all the circumstances considered, many of them may be taken as models of their class, but the slightest thought has been given to the exteriors of the buildings. One plant is located in an old church, another in a dilapidated foundry, and in several cases the compressors, boilers, etc., have been completely placed in the open air and their protective sheds or buildings have been erected over them.

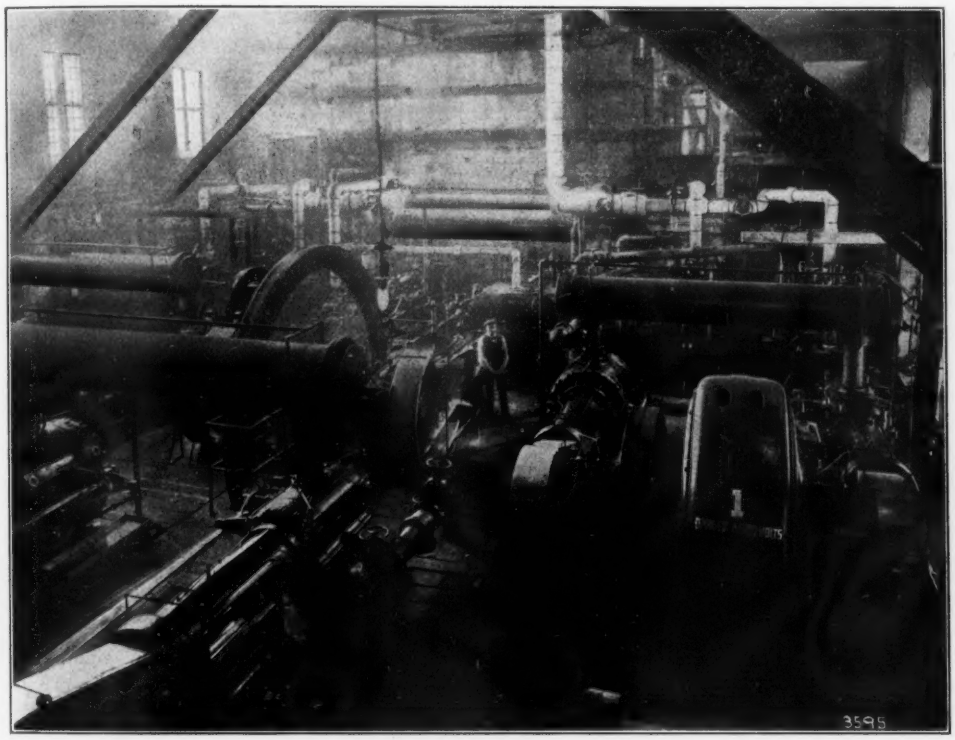


FIG. 3. INTERIOR PENNSYLVANIA TERMINAL POWER HOUSE.

The perfection and endurance of the compressors may be noted as remarkable. The writer hereof more than a year ago personally visited every plant mentioned except that upon

Man-o'-War Reef, the improvised island in the East River, and while most of the compressors seen were being worked to the limits of their capacity, running at speeds which were astonishing, not one was seen out of order or undergoing repairs. The arduous work on the New York aqueduct and in tunnels and mines everywhere has to a remarkable extent revealed and eliminated the weak spots and suggested successive improvements.

FIG. 4. MANHATTAN POWER HOUSE. S. PEARSON & SON.

HIGH SPEEDS.

As indicating the speeds at which these compressors may be run, it may be specially noted that five duplex Corliss compressors, 42-inch stroke, in the Manhattan plant of S. Pearson & Son, Inc., were designed and guaranteed to run continuously at 100 R. P. M., or 700 feet piston speed, with a further provision that in case of emergency they would be capable of running at 125 R. P. M. for a period not exceeding twenty-four hours. This emergency has been encountered several times since the plant was installed, and in fact the machines have run as high as 135 R. P. M., or 945 feet piston speed, for long periods without apparent distress.

In the estimated free air capacities given herein for each plant the piston speed assumed for all is 500 feet per minute. The ¼-inch additional to the nominal diameters of the Ingersoll air cylinders is dropped out of the computations, as this normally compensates for the area of the piston inlet pipe, although in some of the compressors with mechanically operated valves this pipe is not used.

PENNSYLVANIA STATION EXCAVATION.

The work of excavating for the New York terminal of the Pennsylvania Railroad is not at all tunnel work, but it is at the point where four of the tunnels are to meet. This work was, to think of, a simple affair. It was only to dig a hole in the ground; but it was a hole measuring roughly, in the main portion of it, 1,800 by 480 feet and 40 feet deep, with more than a million and a half cubic yards of material to be removed. A considerable portion of the top was sand and gravel, which was removed first, but most of the material is solid rock. Both steam and compressed air are employed on the work. The steam shovels, being self-contained, also some traveling derricks and of course all of the locomotives, are steam operated, while rock drills, pumps, many hoists, concrete mixers, etc., are driven by compressed air, and here, as elsewhere, the compressors are driven to their full capacity.

A temporary compressor plant was first installed right upon a portion of the ground to be excavated, the exterior of the plant being shown in Fig. 1. The church and appurtenances in the background have since been pulled down and rock cutting is proceeding upon the site. There were here three Rand straight-line, Class "C" compressors with cylinders 24 and 26 inch diameter by 30 inch stroke, free air capacity 5,529 cu. ft. per min.,

and one Ingersoll Class "A," piston inlet compressor 24 and 26¼ by 30 inch stroke, free air capacity 1,843 cu. ft. per min. The steam cylinders had balanced valves and Meyer adjustable cut-offs and worked non-condensing. The steam pressure carried was 110 pounds and the air pressure 90 pounds, the latter not being always maintained, as the air was used as fast as it could be delivered. The rock drilling, however, was kept constantly in advance of the work of removal and many holes were always waiting to be fired when needed. The air was not cooled except by the water jacket. There were two large air receivers and a combined delivery pipe 8 inches diameter with valves for disconnecting each compressor. The air line was carried around the excavation with distributing branches where required. There were six locomotive boilers burning small anthracite. A Cochrane feed water heater was in service and two duplex steam pumps for boiler feeding.

It was well to mention this plant first, since it was, with perhaps one exception, the least economical of any of the plants here enumerated. Fig. 2 shows the exterior and Fig. 3 the interior of the more permanent installation of the New York Constructing Company for this Pennsylvania Terminal excavation. This is a plant of much larger capacity and doing its work more cheaply. The building, as is evident, was a church, but the interior is now as unecclesiastical as could well be imagined.

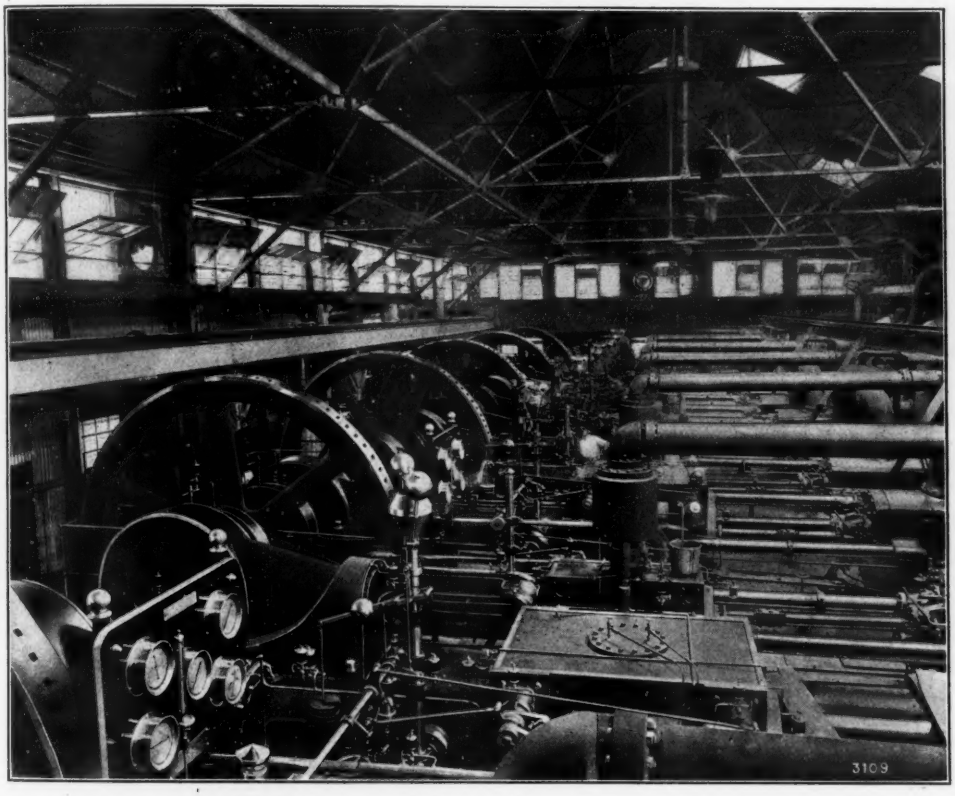


FIG. 5. INTERIOR S. PEARSON & SON'S MANHATTAN POWER HOUSE.

There are here three two-stage, electric-driven R. D. 2 compressors with air cylinders 30 and 19 inch diameter by 30 inch stroke; free air capacity, 8,983 cu. ft. per min. The induction motors are each 500 h. p. General Electric, Type LM, 122 revolutions per min., 6,600 volts, 3 phase, 25 cycle. There is also one Rand Corliss, cross compound, I girder frame, two-stage compressor with steam cylinders 22 and 40 and air cylinders 38 and 23 by 48 inch stroke; free air capacity, 3,937 cu.

ft. per min. In addition to these are the four compressors of the temporary plant previously enumerated and therefore here not mentioned further and not repeated in our final summary of the various plants.

steam cylinders 16 and 34 by 42 inch stroke, with duplex air cylinders 26¼ inch for a maximum air pressure of 50 pounds; free air capacity, 14,744 cu. ft. per min. There is another cross compound Corliss compressor of the

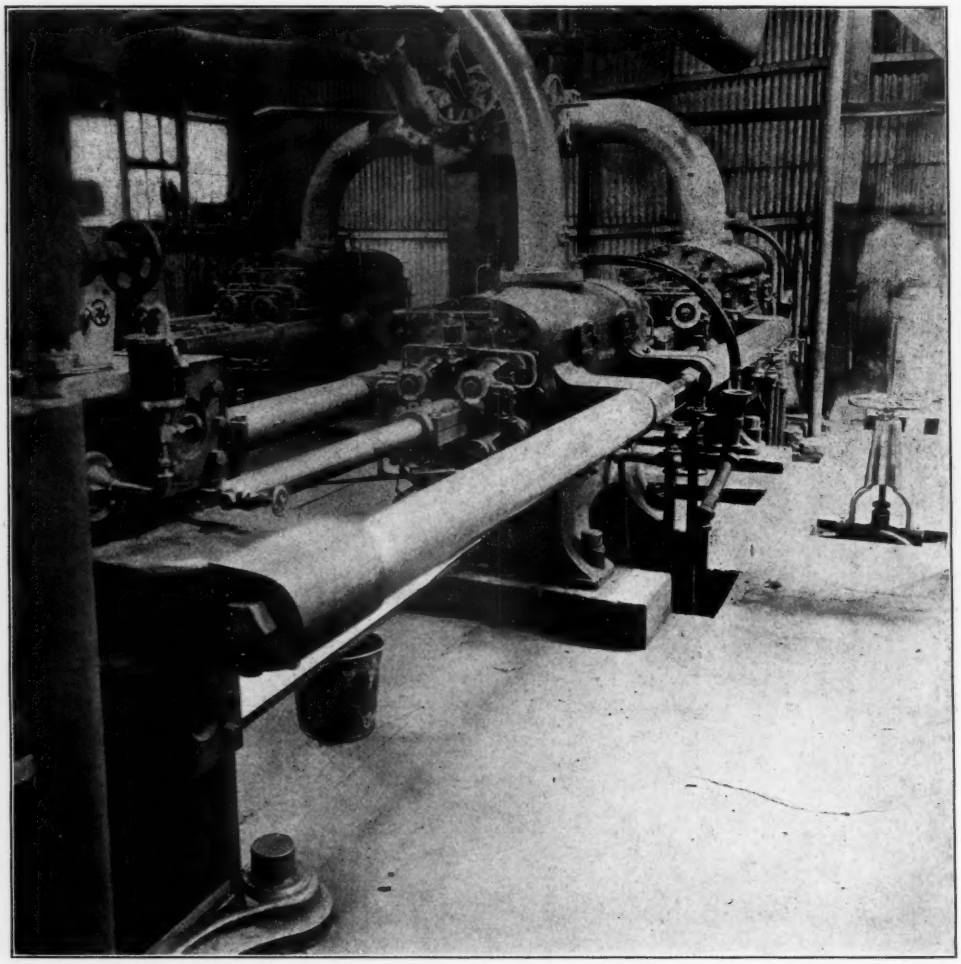


FIG. 6. TANDEM AIR CYLINDERS ON SPECIAL COMPRESSOR.

PENNSYLVANIA RAILROAD EAST RIVER TUNNELS MANHATTAN PLANT.

The plant of the contractors, S. Pearson & Son, Inc., at Thirty-third street and First avenue, New York, is in marked contrast to the preceding. Fig. 4 is a snapshot of the exterior and Fig. 5 shows the interior. The entire equipment in this case was installed under the direction of the builders of the compressors, the Ingersoll-Rand Company. There are four cross compound Corliss compressors with same stroke and with the same cylinder dimensions as the above, but with duplex air cylinders 15½ inch diameter designed to compress to 140 pounds air pressure. The air for this compressor may be taken into the cylinders at the atmospheric pressure or it may be taken in at 40 or 50 pounds pressure from the aftercooler of the low pressure service, thus increasing its delivery at the high pressure about fourfold. Free air capacity, 1,310 cu. ft. per min. Another compressor has a

special combination feature. It is a cross compound Corliss compressor with the same cylinder dimensions as above, but with tandem air cylinders 23¼ and 15½ daimeter on each side. These cylinders on one side are seen in Fig. 6. All the air cylinders may be used to compress atmospheric air to 50 pounds pressure and deliver individually into the low pressure service or by disconnecting the 23¼ inch cylinders the smaller cylinders may be used for the high pressure service, 140 pounds, precisely the same as the preceding machine. Free air capacity of this compressor, 4,194 cu. ft. per min. Besides these there are two straight-line, Class "A" compressors 18 and 18¼ by 24 inch stroke, used for preliminary development work and generally held in reserve. Free air capacity, 1,766 cu. ft. per min. This is the plant mentioned above guaranteed to work up to a piston speed of 700 and in emergencies to 875 feet per minute, and which has been run up to 945 feet in actual work.

There are here six 500 h. p. Sterling boilers, three Wheeler condensers, with independent Edwards air pumps, three centrifugal pumps of the Buffalo Forge Company supplying water from the East River for jackets, intercoolers, aftercoolers and condensers, duplex boiler feed pumps in duplicate, a separate system of gravity lubrication, a special loop steam system with Holly drip arrangement and a chemical oil separator. A working steam pressure of 150 pounds is carried throughout and everything possible is run condensing except what is required for heating the feed water. The power house contains three high speed engines with direct connected generators and three duplex high pressure hydraulic pumps automatically controlled to supply water for advancing the shields, with which we here have nothing to do. Total free air capacity of plant, 22,014 cu. ft. per min.

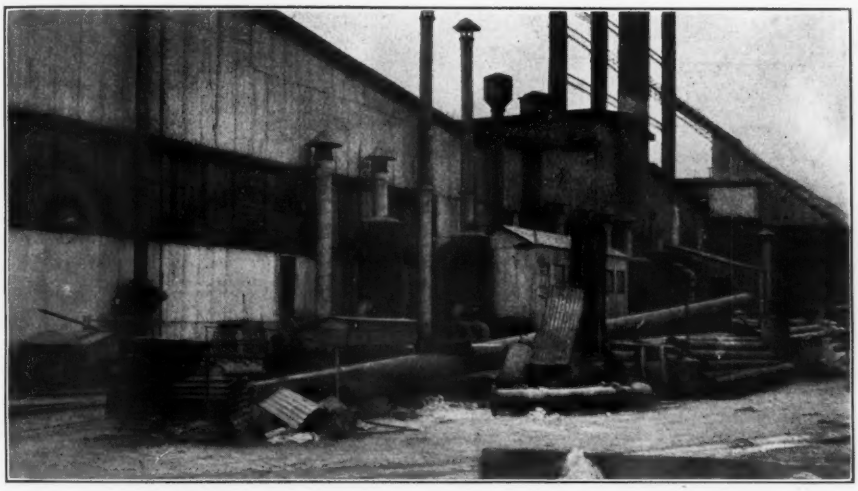


FIG. 7. LONG ISLAND CITY PLANT. S. PEARSON & SON.

PENNSYLVANIA RAILROAD EAST RIVER TUNNELS LONG ISLAND CITY PLANT.

This plant of S. Pearson & Son at Flushing street and East River has the same units as the above, except that it has no Class "A" compressors, and the entire plant is quite differently arranged, the large yard space allowing great length for the power house. Fig. 7 is a snap-shot of the exterior. The vertical pipes will be noticed, capped with strainers for the intake air. Instead of the Class "A" compressors an additional Corliss compressor, the same as the others for low pressure air, was installed, making the total free air capacity of the plant at 500 feet piston speed—23,934 cubic feet per minute.

PENNSYLVANIA RAILROAD NORTH RIVER TUNNELS, MANHATTAN PLANT.

The plant of the O'Rourke Engineering Construction Company at 33rd street and 11th avenue, New York, the general exterior of which is shown in Fig. 8, comprises three cross compound Corliss compressors with steam cylinders 14 and 30 by 36 inch stroke and duplex air cylinders 23¼ inch diameter for maximum air pressure 50 pounds. Free

air capacity, 8652 cubic feet per minute. There is also one cross compound Corliss compressor with steam cylinders 14 and 22 by 36 inch stroke and duplex air cylinders 14¼ inch to compress to 140 pounds, using either free air or air taken from the aftercoolers of the low pressure compressors. Free air capacity, 1068 cubic feet per minute.

cylinders 36¼ and 22¼ inch diameter. The engine has its own air pump and condenser. Free air capacity, 3534 cubic feet per minute. This compressor was originally installed at Jerome Park Reservoir, where it was in service about six years. Besides this, there are two Ingersoll Class "A" compressors, 24 and 24¼ by 30 inch stroke, free air capacity 3140 cubic

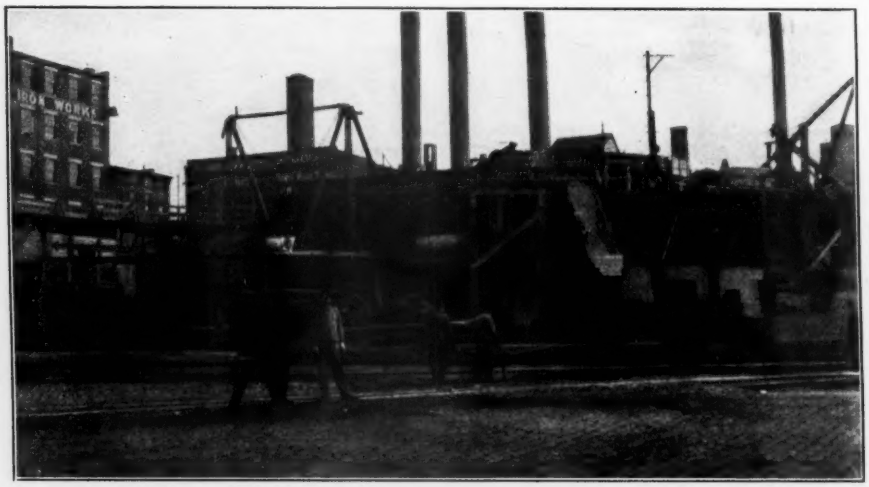


FIG. 8. MANHATTAN POWER HOUSE. O'ROURKE ENGINEERING CONSTRUCTION CO.

PENNSYLVANIA RAILROAD NORTH RIVER TUNNELS, WEEHAWKEN PLANT.

This plant, also of the O'Rourke Engineering Construction Company, foot of Baldwin avenue and North River, Weehawken, N. J., is an exact duplicate of the preceding. Total free air capacity, 9720 cubic feet per minute. The interior of this plant is seen in Fig. 9.

PENNSYLVANIA RAILROAD TUNNEL UNDER BERGEN HILL.

This plant of the John Shield's Construction Company at Hempstead, N. J., comprises one Ingersoll Class "A" compressor, 24 and 24¼ by 30 inch, free air capacity, 1570 cubic feet per minute, and four Rand Class "C" 24 and 24 by 30 inch, free air capacity, 6280 cubic feet per minute.

NEW YORK AND BROOKLYN SUBWAY TUNNEL, BATTERY PARK, MANHATTAN.

The principal compressor in this plant of the New York Tunnel Company, the contractors, is an Ingersoll cross compound Corliss, steam cylinders 24 and 44 inch diameter and 48 inch stroke with two-stage piston inlet air

feet per minute. There are two Heine and two Hogan water tube boilers.

NEW YORK AND BROOKLYN SUBWAY TUNNEL, JOROLEMON AND FORMAN STREETS, BROOKLYN.

This plant, while of considerably larger total capacity than that at Battery Park, has for its largest unit the other Jerome Park Reservoir compressor, an Ingersoll cross compound Corliss with steam cylinders 24 and 44 inch diameter by 48 inch stroke and single stage, piston inlet, air cylinders 24¼ inch diameter. Free air capacity, 3140 cubic feet per minute. This compressor also has its own air pump and condenser. There are also two Ingersoll cross compound, Class "GC" compressors with steam cylinders 22 and 34 inch diameter by 24 inch stroke and single stage piston inlet air cylinders 30¼ and 28¼ inch diameter. The difference in the diameters of these cylinders is due to the exigencies of manufacture when the machines were required at very short notice. These compressors were not required to compress the air to above 25 or 30 pounds. Free air capacity, 9184 cubic feet per minute.

There is one Rand Class B-4 cross compound compressor with single-stage air compression, steam cylinders 20 and 32 inch diameter by 30 inch stroke and air cylinders 26 inch diameter. Free air capacity, 3686 cubic feet per minute. Two Ingersoll Class "A" straight-line piston inlet compressors 24-inch steam and 24¼-inch air by 30-inch stroke. Free air capacity, 3140 cubic feet per minute.

BELMONT EAST RIVER TUNNEL PLANTS.

As these were the subject of a previous article we here merely enumerate the sizes and capacities of the compressors employed. At 42nd street, Manhattan, there is in one power house a Rand cross compound Corliss two-stage air compressor with steam cylinders 24 and 40 by 48 inch stroke and air cylinders 39 and 24 inch; free air capacity, 4147 cubic feet per minute, and an Ingersoll cross compound Corliss two-stage compressor with steam cylinders 22 and 40 by 42 inch stroke, and air cylinders 38 and 24 inch; free air capacity, 3937 cubic feet per minute. In the other power house there are three Ingersoll cross compound steam, duplex air class "H" compressors with steam cylinders 15 and 28 by 16 inch stroke and air cylinders 20¼ inch diameter for a maximum pressure of 50 pounds; free air capacity 6540 cubic feet per minute. There is also an Ingersoll cross compound steam, two-stage air, Class HC compressor with steam cylinders and stroke as above, but with air cylinders 25¼ and 16¼ inch diameter for 100 pounds air pressure. Free air capacity 1704 cubic feet per minute. Fig. 10 shows one of those compressors being set up in place before the house was built over it.

On Man-o'-War's Reef there are three duplex Class "J" Ingersoll belted compressors with air cylinders 20¼ inch diameter by 18 inch stroke for 50 pounds pressure; aggregate free air capacity, 6540 cubic feet per minute; one electric belted two-stage machine for 100 pounds pressure with air cylinders 25¼ and 16¼ diameter by 18 inch stroke; free air capacity, 1704 cubic feet per minute., and two Ingersoll Class "A" straight line compressors, 24 inch diameter, steam, 26¼ diameter air by 30 inch stroke; free air capacity, 3686 cubic feet per minute.

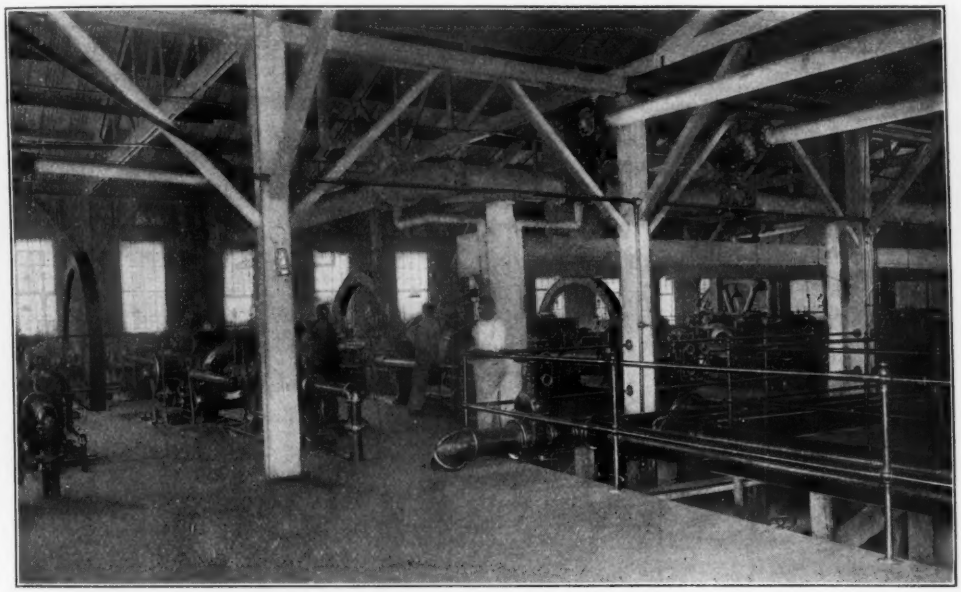


FIG. 9. INTERIOR WEEHAWKEN POWER HOUSE.

At the Long Island City plant there are two Ingersoll cross compound steam, two-stage air, Class "H" compressors with steam cylinders 15 and 28 by 16 inch stroke and air cylinders 25¼ and 16¼ for 100 pounds air pressure; free air capacity, 3408 cubic feet per minute. There are here also two Ingersoll Class "A" compressors 24 and 26¼ by 30 inch

stroke; free air capacity, 3686 cubic feet per minute and one Class "A" compressor 24 and 24¼ by 30 inch stroke; free air capacity, 1570 cubic feet per minute.

HUDSON COMPANIES—NORTH RIVER TUNNELS, MORTON STREET, MANHATTAN.

This pair of tunnels now completed was begun, or one of them, a quarter of a century ago, the work having been stopped by serious accidents and financial difficulties. The final plant here comprised one duplex Rand compressor 22 and 22 by 24 inch stroke, free air capacity 2640 cubic feet per minute; one Ingersoll Class "A" 22 and 22¼ by 24, free air capacity 1320 cubic feet; one Ingersoll 20 and 22¼ by 24, free air 1320, and an Ingersoll 16 and 16¼ by 18, free air 698.

FIG. 10. ERECTING COMPRESSORS BEFORE THE BUILDING.

HUDSON COMPANIES—NORTH RIVER TUNNELS, 15TH STREET, HOROKEN, N. J.

This plant is located immediately opposite the preceding, working at the other ends of the same tunnels and continuing them westward into the land. There is one compressor here which was sold to the Hudson River Tunnel Company in 1880 and overhauled in 1890 which was still doing good service until the work was finished. It is now rated as an Ingersoll Class "A", 20 and 20¼ by 30 inch stroke, free air capacity, 1089 cubic feet per minute. There are also two Ingersoll Class "A" compressors 22 and 26¼ by 24 inch free air capacity 2686 cubic feet per minute and one Ingersoll duplex Class "H" compressor 16 and 20¼ by 16 inch stroke, free air 2178 cubic feet per minute.

HUDSON COMPANIES—NORTH RIVER TUNNELS, NEAR PENNSYLVANIA STATION, JERSEY CITY, N. J.

The tunnels here being driven are to enter New York City near Cortlandt street; there is no plant opposite, the tunnels being driven entirely from their western ends. There are here three Ingersoll Class "HC" cross compound steam, two-stage air, compressors for high pressure air, and three Ingersoll Class "H" cross compound steam and duplex single-stage air compressors for the low pressure air. The former are 14 and 28 inch steam and 24¼ and 14¼ air by 16 inch stroke, free air capacity, 4710 cubic feet per minute, and the latter are of the same steam dimensions with air cylinders 22¼ by 16 inch, free air capacity, 7920 cubic feet per minute.

HUDSON COMPANIES—NO. 4 PLANT, WASHINGTON STREET, JERSEY CITY.

This plant has been employed upon land tunnels connecting the two preceding. It comprises two Rand Class "B" compressors, cross compound steam cylinders 18 and 30 inch, and two-stage air cylinders 26 and 15 inch by 30 inch, free air capacity 3686 cubic feet per minute, and two Rand Class "B" compressors with steam dimensions as above and duplex air cyl-

inders 23 inch diameter by 30 inch stroke, free air capacity, 5768 cubic feet per minute.

SUMMARY OF TUNNEL PLANTS.

The total free air capacity of all the compressors here enumerated is 191,291 cubic feet per minute, which would be represented by a cube with a side of over 57 feet. The total number of compressors is 80, most of them approaching the largest sizes built. The actual horse power employed has not been computed on account of the differences in the air pressures, but probably was not less than 40,000. The number of steam cylinders is 120 and the number of air cylinders 138. That these compressors have been kept constantly running, mostly night and day, and generally at speeds which would be considered excessive, is something for the builders, the owners and the operators to be proud of. Whatever delays have occurred, whatever accidents have happened, whatever of the unforeseen has been encountered, the air compressors have been always ready, always efficient and always to be relied on.

It will be seen that the compressed air for this tunnel work is delivered and used at two quite different pressures, requiring two different classes of compressors and separate pipe lines for transmission. The low pressure air for the shield work is generally used at pressures between 20 and 30 pounds, the compression of this air is single-stage and the compressors are usually guaranteed for a maximum of 50 pounds. The high pressure air for operating the drills is required to be higher than the normal for such work, as the air from them is exhausted against the air pressure of the shield. The air for this service is carried at pressures above 100 pounds up to 140 or 150 pounds, the compression being two-stage with of course efficient intercooling. Many of the installations also include after-coolers, which are found to contribute to economy of operation, giving drier air and reducing the volume during transmission without any ultimate reduction of volume when the air is used at the end of the line.

The usual conditions of steam economy are insisted upon throughout these plants. Steam is carried at pressures up to 150 pounds, the steam ends of the compressors are generally compounded, and condensing apparatus is usually installed for each entire plant whether the individual units are compounded or not. The automatic regulation of the speeds of the compressors according to the varying demands of the service has been a notable and successful feature.

Much the larger volume of the air compressed has been for the low pressure service to oppose the inrush of water, and passengers on the East River ferries have seen the water actively boiling with the escape of this air, so that most of it may in a way be said to have been lost or wasted. Under the most favorable conditions the use of air in subaqueous tunnels is a very different problem from that of the vertical caisson. In the latter the pressure adjusts itself precisely to that of the surrounding water, the air escaping under the edge when the pressure is at all in excess, and the compressor supplying a caisson has only to make up for the losses in the air lock and to renew the air sufficiently for safe respiration.

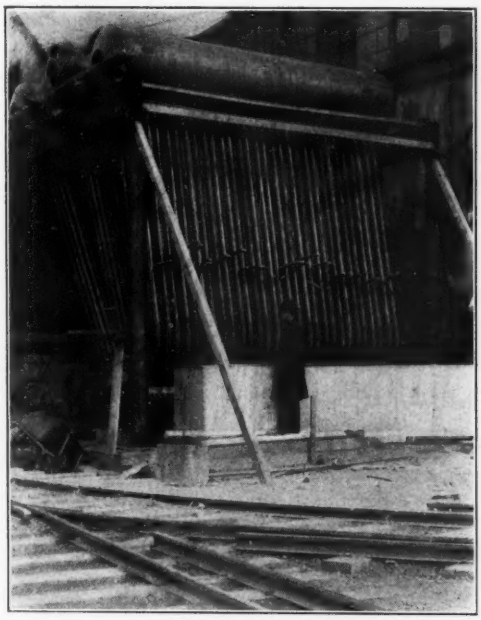


FIG. 11. EXTENDING BOILER HOUSE.

When the air pressure at the top of the tunnel is sufficient to balance the pressure of the water and hold it back the air pressure at the bottom of the tunnel will be five or six pounds too light, and if the pressure is increased to balance the water pressure, at the bottom then it is able to blow off at the top with considerable force, and where the superincumbent material is in a soft or semi-fluid condition the

air finds its way through it in all directions. The compressors in this service were constantly worked to their utmost in the struggle with the soft mud waiting to rush in, and only a very unstable equilibrium could be maintained at the best.

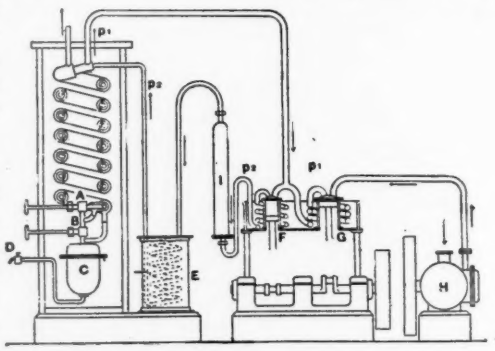
INDUSTRIAL LIQUEFACTION OF AIR

An extensive plant for producing oxygen from liquid air on an industrial scale is now being erected in Buffalo by the Linde Air Products Company, Dr. Linde's system of air liquefaction and subsequent rectification being applied. The following information concerning this interesting installation has been given to *Electrochemical and Metallurgical Industry* by Mr. Cecil Lightfoot, consulting engineer and general manager of the company:

The action of the Linde apparatus for producing liquid air is based on the refrigerating effect resulting from an expansion of air from a higher to a lower pressure and which is due to the performance of internal work. The action of any desired number of expansions is accumulated and intensified by causing each preceding expansion to act as a fore-cooler for the air for the following expansion. Since the refrigerating action depends upon the difference of pressure before and after expansion, while the work of compression corresponds to the ratio of these pressures, it is advantageous to select a large difference in pressures but a small ratio of pressures. In the Linde apparatus air is expanded from an initial pressure of about 200 atmospheres to about 50 or 20 atmospheres, so that the difference of the pressures varies between 150 and 180 and the ratio is between 4 and 10.

As will be seen in the cut, a triple coil is provided which is composed of copper tubes placed one within the other. This is called the heat interchanger. Air compressed to 200 atmospheres flows downward through the innermost coil, at the lower extremity of which it is allowed to expand to an intermediate pressure of 20 to 50 atmospheres. The expanded air is then returned through the annular space between the innermost and middle coils to the top, when it is again compressed up to 200 atmospheres pressure and the cycle is repeated. Immediately behind the first regulating valve A is placed a second valve B, through which, when the operation of the machine has been brought to a state of equilibrium, a small quantity of air is allowed to escape at atmospheric pressure, a corresponding amount being introduced into the cycle from the surrounding atmosphere. Part of this air leaves the second regulating valve in the liquid state and collects in the vessel C; the remaining portion is returned to the atmosphere through the annular space between the middle and outer coils. The liquid air is drawn from the collector by means of the small cock D.

In the larger installations the necessary compression of the air is effected by means of a high-pressure air pump, which is usually arranged for two-stage compression, working in conjunction with a single-cylinder low-pressure air pump. The high-pressure cylinder F of the former draws the partly expanded air from the heat interchanger at an intermediate pressure of about 50 atmospheres, and compressing it up to 200 atmospheres pressure, delivers it to the interchanger again through the cooler E. The air which is to be added to the cycle as "make-up" is supplied by the low-pressure air pump H, which draws it from the atmosphere, compresses it to a pressure of 4 atmospheres and delivers it to the low-pressure cylinder G of the high-pressure air pump, where it is compressed to a pressure of 50 atmospheres. At this pressure it enters the high-pressure cylinder, together with the partly expanded air from the heat interchanger, as described above.



AIR LIQUEFYING APPARATUS.

Low-pressure compressors are not usually supplied with the smaller sizes of air-liquefying plants, the lower pressure of the cycle being in such cases maintained at 20 atmospheres and the low-pressure cylinder G drawing the "make-up" air direct from the atmosphere.

Regulation of the several pressures is performed with the aid of pressure gauges by means of regulating valves in the heat interchanger. Safety valves are provided to prevent the maximum pressures being exceeded.

In electric-furnace operations when electric energy is expensive, it is advantageous to preheat the charge or to start at once with a molten charge so as to produce only the highest temperatures from electrical energy, in order to save in the consumption of the expensive electrical energy. In the liquefaction of air where the object is to get a very low temperature it is advantageous in quite an analogous way to pre-cool the air. For this purpose a fore-cooler is provided by means of which the compressed air is reduced in temperature to 5 or 10 degrees above zero Fahrenheit, by refilling the receptacle provided for the purpose with a suitable freezing mixture, such as ice and salt. This is practical in smaller installations.

On the other hand, with large installations, the preliminary cooling of the air is preferably brought about by a small belt-driven refrigerating machine on the ammonia compression system. The adoption of fore-cooling is advisable in all cases, but especially when the cost of power is an item of great importance.

Between the compressor and the fore-cooler, apparatus is provided for separating water from the compressed air. This apparatus is provided with a suitable drain cock. Further extraction of the aqueous vapors from the compressed air with the smaller installations is performed in the fore-cooler. In larger plants the drying process is effected after the last stage of compression by means of chloride of calcium placed in the dryer supplied with the machine.

If the liquid air is to be used for the production of pure oxygen and pure nitrogen it is subjected to a process of rectification which is very similar to the process employed in spirit distilleries for the separation of alcohol and water. In this way it is possible to get oxygen 95 per cent. pure, and if the output is reduced by 10 or 20 per cent. the purity of the oxygen may be brought up to as much as 98 or 99 per cent. The chief advantages of this method of producing pure oxygen are claimed to be low expenses, simplicity and safety in work, and the freedom of the oxygen from water vapor, chlorine, etc. The residual gases entirely consist of the ordinary nitrogen constituents of the atmosphere.

An interesting application of nitrogen produced from air in this way is in the production of calcium cyanamide. Five Linde plants are already at work in Europe on a very extensive scale for this purpose alone, whilst other and still larger installations are now in course of construction, so that the industry appears to be already well established. It will be remembered that for the production of cyanamide, calcium carbide is treated in a nitrogen atmosphere at an elevated temperature. It is, therefore, necessary to first get the nitrogen from air. The question then comes up what to do with the oxygen, and while there are, of course, many applications like its use in blow-pipes, etc., the interesting suggestion has been made to use the oxygen for enriching atmosphere air in oxygen and then to treat the latter by electric arc discharges to produce nitrogen oxides for the subsequent manufacture of nitric acid and nitrates. In this way the two methods which have so far been found practical for the fixation of atmospheric nitrogen would work side by side; the nitrogen obtained from the liquid air would be used in the calcium cyanamide manufacture and the oxygen would be used in the nitric acid manufacture.

Altogether, about 100 liquid air plants on Dr. Linde's system have already been supplied, of which nearly half are employed either for the production of oxygen or of nitrogen in the pure state, or of both.

Liquid air at atmospheric pressure boils at 312 degrees Fahrenheit. As the more volatile nitrogen evaporates the color of the liquid assumes a bluish tinge, the color of liquid oxygen. Vacuum vessels are necessary for the storage of liquid air, oxygen and other gases which have these low boiling points. These vessels, generally cylindrical or globular, consist of two similar glass vessels but one considerably smaller than and contained in the other, the two being hermetically united at their necks. The space between the two vessels is then roughly exhausted and sealed under a high permanent vacuum. The rate of evaporation of liquid air in these vessels is approximately 5 to 15 per cent. of the original volume in 24 hours. As evaporation only takes place from the surface of the liquid, the size of the vessel is an important factor in determining the time the air can be stored. If

allowed to rest in a quiescent state evaporation is much less rapid than if subject to vibration or larger movements. Vacuum vessels of half a gallon capacity and upwards should not be tilted to pour out the liquid, as the sudden cooling of the glass at the neck and the consequent local contraction might crack the vessel. A small hand pump is a convenient device for emptying vessels without tilting or inverting.

PORTABLE PNEUMATIC TOOLS

The above is the title of a paper read recently before the Institution of Mechanical Engineers by Mr. Bing. Attention was called to the numerous improvements in these tools and to the new tools which have appeared, especially in Great Britain, since the century began. The principal typical uses to which the various tools are put, and especially the effect of their use on the cost of production, was also gone into, showing substantial progress in the last six and a half years in both the tools and the range of their work. Pneumatic tools are now found in use in practically all engineering works, shipyards and mines, not only in America and Great Britain, but all over the world, and in addition, they are largely used by contractors everywhere on constructional work of steel, stone and wood. Not only have the various trades concerned availed themselves largely of the advantages offered by these tools, but at the present time there are many engineering firms in this country engaged in their manufacture; also, the tools produced by them compare very favorably, with regard to accuracy of workmanship and quality of the material employed, with those made on the other side of the Atlantic. Users doubtless might be found who would say that there is still considerable room for improvement, and that the length of life of all kinds of pneumatic tools is not what it should be.

Generally speaking, ordinary work is now done by these tools at a price for labor equivalent to a reduction of from 35 to 60 per cent. off hand labor rates, but on work at all awkward to get at with hand tools the reduction would be greater still. With regard to scaling boilers by pneumatic hammers, Messrs. John Allen & Sons, of Kilburn, give the following comparative figures, one boiler—Cornish, 30 ft. by 6 ft.—only being referred to, the average thickness of scale being 3/8 in. The two pneumatic hammers weighed 9¾ lbs. each, with pistons 1 1-16 in. diameter, and 1¾ in. stroke. When the work was done by hand eight men at 18 cents per hour were employed for nine hours per day, each man receiving 60 cents per day extra as "dirt" money. The job took six days.

Cost per day: Eight men at $2.30.. $13.40
Cost for the six days.....110.40

With two pneumatic hammers, four men employed, two using the pneumatic hammers and two their hand tools, the same job took but three days.

Cost per day: Four men at $2.30..$ 9.20
Cost for the three days..... 27.60
The saving of labor thus being.... 82.80

The riveting hammers are now capable of closing rivets up to 1½ in. diameter, and are employed in all kinds of constructional iron work, both in the yards and in the field; on boiler work, on furnaces, combustion chamber, and shell plating, and in shipbuilding for both shell, bulkhead and deck riveting.

Of all ship work deck riveting is perhaps the easiest to do, because the deck below usually forms a convenient means for supporting the pneumatic holder-on, and where an open hatchway occurs, a plank can readily be laid across. The riveting hammer, too, being used in a vertical position and downwards, is easily held and directed. With practice many riveters become so expert that they prefer to dispense with the carriages provided to support the hammers, and, given a good run of work, reamered holes, plates well bolted up, a good rivet forge, and a smart boy, will make good money at a rate only one-half of that given for similar work done by hand. Much bulkhead riveting is done with the aid of the spring dolly-bar for holding up, especially under conditions in which it is difficult to arrange to support the ordinary pneumatic holder-on.

The amount of boiler riveting done by pneumatic hammers is gradually increasing, and pneumatic tools are to-day employed on all types of boilers, the rivets so driven in many marine boiler shops satisfactorily passing the tests imposed by the Board of Trade and Lloyd's surveyors.

The improvement in pneumatic riveting by the use of the double piston holder-on was so marked that a hammer type holder-on is being introduced, the piston of which is really a valveless pneumatic hammer. Its piston is

actuated by the air which is admitted to the back end of the containing cylinder to drive it forward. In use, both hammers strike the rivet together, but, after the head of the rivet has been well set up, the holder-on hammer is stopped by closing the exhaust passages and the point of the rivet finished off, while the head is supported by the holder-on acting in the usual way. By the use of a pneumatic hammer in combination with a holder-on, the operation of which is under control, it will be seen that, under all ordinary conditions of working, the rivet hole at the head can be quite as well filled as at the point, provided the rivet is well heated its whole length, and that it is also insured that the head itself shall be tight up against the plate.

Pneumatic drills continue to form a most important item in the machine equipment of nearly all engineering and shipbuilding works, and since 1900 the number of these machines in use in Great Britain has increased tenfold, a fact strikingly significant of their general utility. On work to which these machines were first applied, such as drilling out stays in repairing boiler fire-boxes of all kinds, driving combustion chamber and fire-box stay-taps, stay-tube taps, turning in stays after tapping the holes, all kinds of drilling and reaming in shipbuilding work, drilling on constructional iron work, etc., they have more than held their own, and the portable electric drill has not yet ousted them from the premier place. The rates paid for pneumatic drilling now vary from 40 per cent. to 75 per cent. off rates paid for hand drilling, depending on the nature of the work. In many shipyards, including the government dockyards, all rivet holes are now reamered out by pneumatic drills. To obtain the best results with wood augers operated by pneumatic drills running at a speed of from 400 to 650 revolutions per minute, the screwed points of the augers should have a pitch of not coarser than twenty threads to the inch. The pitch of the screw, on the point of the ordinary hand auger, is from 8 to 12 to the inch generally, and is much too coarse. Attention to this detail is of the greatest importance. Most of the difficulties attending the use of these portable drills for mining work—drilling or boring in coal or ores—have now been overcome, and various sizes and makes of drills, fitted specially for the work, are now in regular employment, and the number is steadily increasing.

In the design of pneumatic sand-sifters a rectangular-shaped sieve is used, which is mounted on four rollers attached to the top horizontal bars of the frame. It is shaken or vibrated by a valve type of pneumatic hammer of simple construction mounted on the back bracket of the frame, the sieve being attached to the hammer piston by a suitable connection. The sieve is slightly inclined downwards from the hammer, and the lower end is open and comes over the shoot. When working, the coarser parts of the feed are worked along down the incline and out of the sieve at the shoot, while the finer sand falls through between the four legs. Under ordinary conditions of working these machines require two men to shovel sand into the sieve if they are to be kept fully employed. The sieve measures 36 in. by 18 in., but is open for a length of 18 in. only, and the mesh varies from ¼ in. to ½ in. The coarser material passes over the whole length of the sieve on its way to the shoot, and its thorough screening is thus insured, while having the sieve open for only half its length prevents it being overloaded when working. Pneumatic sand-sifters are also arranged for fixing to a post or wall.

Pneumatic sand-rammers are now beginning to play an important part in general foundry and concrete work, such as ramming moulds and cores, tamping concrete clay, road foundations, trenches, etc. Rammers ranging from 7 lbs. in weight with pistons ⅞ in. in diameter and 4 in. stroke to those weighing 280 lbs. with a piston 3 in. in diameter and a 10 in. stroke, striking a maximum blow of over 350 lbs., are now made and are in general use, but more so, perhaps, in the United States than elsewhere. The hammer barrel is longer than that of the ordinary pneumatic hammer, giving a long piston stroke, and the piston is hollow and projects through the front end of the cylinder, the ramming heads being attached to it. The lever for controlling the admission of air is placed so that the operator's hand covers it when the tool is held in the working position. The weight of the blow is regulated by the distance the rammer head is held from the work, the heaviest blow being struck when the piston is allowed to travel its full stroke, and lighter but more rapid blows when the rammer is held closer, consequent on the shorter strokes then made. The front end of the piston to which the rammer heads are attached is hexagon in shape, so that the head can

not turn except at the will of the operator. Rammers up to 45 lbs. in weight are handled by one man, but those above this weight are generally suspended to a swinging arm in such a way that they can be readily moved about over the work and raised and lowered as required. Concrete, when rammed in moulds by these tools, sets into sound hard blocks, as the frequent tamping works the air out and packs the sand and cement together very closely. The small hand-rammers enable a man to get through a given amount of work in from one-half to one-quarter the time it would take were he using hand-rammers, and the largest rammer will do as much work as eight to twelve men with hand-rammers.

Compressed air is now used to remove foul air or gas from ships' water and ballast tanks before scaling and painting. It is also used when patented pitch compound is being applied, to carry off the unbreathable noxious yellow smoke given off by the compound, which is put on over a coating of coal tar at a temperature as near boiling point as possible. This work is done in dry dock, and the practice is to knock out a shell rivet as far away from the manhole in the tank top as possible, and attach a hose-pipe to convey the air. When turned on the air effectually drives out the foul gases, and makes it possible for men to remain in the tanks when the hot pitch compound is being applied. In painting the inside plating of ships, the plates, when the ship is afloat, are often wet to a good distance above the water line by condensation of moisture from the atmosphere on the cold surface. Paint will not adhere to plating in this state, but the surface may be easily dried by blowing compressed air over it for a short time, and quickly made ready for painting.

THE USE OF SAND BLAST BY ELECTRIC RAILWAYS

By J. M. Betton.

Although the sand blast has been used in electric railway work for a number of years, its adoption has not been so general as would seem to be warranted by its efficiency and convenience. With only ordinary care and attention it will do good work, and it is especially adapted to electric railways because power for operating an air compressor is always available at any point. An air compressor, either direct connected to the motor or driven by a belt, is easily procured, as is also a steel tank to be used as an air receiver. Consequently there only remains to be selected a sand blast equipment with the proper nozzles, hose, couplings, etc.

Some companies prefer to make their own sand blast apparatus or to use anything that will throw a jet of sand, and perhaps in many cases, as power is so easily obtained, this may appear justifiable. However, it is well to recognize the fact that the machine that will last the longest, stand the knocks and rough handling that come to it, and that is the most economical in its use of air and sand in actual use is the best in the long run. On a street railway, as in any other sort of plant, the saving of small quantities of power and the stoppage of leaks are always worth while, and it is not workmanlike or good business to use a makeshift that wastes power, which always costs the company money. Good sand blasts are obtainable at prices which are more than reasonable when one considers the time and experimenting required to get up a home-made affair.

Sand blast outfits should be of such design that the air supply can be regulated, and if this is applied at several points instead of in bulk at one point, better economy will be obtained. One great advantage is that the air compressor, air receiver and sand blast can be mounted on a truck which will follow the work, obtaining its power from any feed wire.

One of the most important uses of such sand blast outfits is in their use for cleaning the ends of rails previous to bonding. For this work, with a 3/8-in. nozzle and 35 lbs. of air pressure, 100 cu. ft. of free air per minute are required.

It will be noticed that the steel poles used to support the feed or trolley wires often become corroded for a foot or two upward from the base. If no remedy is applied the corrosion will in time undermine the strength of the posts and renewal will be necessary. All of the rust, dirt, scale and accumulation may be removed by the sand blast, leaving a new surface of the clean gray iron or steel, which may be protected by a covering of concrete or cement, thus materially prolonging the life of the pole. This work requires about 35 lbs. of air pressure and can be done quickly with a 1/2-in. nozzle, using clean, dry and moderately fine sand and 179 cu. ft. of free air per minute.

Similarly all steel structural work, such as bridges, viaducts and elevated railway supports, can be perfectly and quickly cleaned by the sand blast, using preferably a ½-in. nozzle and 35 lbs. of air, increasing the pressure to about 50 lbs. if the sand has to be carried to more than ordinary height. Corners, angles, recesses and other portions of the structure that cannot be reached in cleaning by hand can be cleaned as readily as the plane surfaces of the members.

In all such work the painter's gang should follow closely after the sand blasters, as oxidation is rapid and the object of cleaning by the sand blast is to expose the raw metal, which, being freed from rust, will hold the paint that otherwise would scale off. In like manner steel shapes in stock can be cleaned when wanted for use.

Another use of the sand blast is in the cleaning of the exteriors and interiors of burnt-out controller boxes on electric cars. These are usually cleaned by hand, but the sand blast will do the work four or five times quicker and with greater thoroughness. A pressure of about 25 lbs. and a ⅜-in. nozzle, requiring 77 cu. ft. of free air per minute, can be used to advantage.

The grids from storage batteries that have run down can also be cleaned with the sand blast previous to refilling, using a ⅜-in. or ¼-in. nozzle and about 20 lbs. air pressure, requiring from 31 to 69 cu. ft. of free air per minute. This work should be done out of doors, and the grids should be wet, as the particles of lead and dust are injurious if inhaled.

The bodies of steel cars can be freed from old paint, rust, scale and dirt in the quickest manner by the sand blast, using a ½-in. nozzle under 35 lbs. of air pressure, requiring 179 cu. ft. of free air per minute, and the running gear can be also thoroughly cleaned with the same pressure.

These are only some of the uses of the sand blast in electric railway work, and besides cleaning ornamental work, brasses, etc., its use can be greatly extended in the repair shop and along the line. Considering the ease of operation, the thoroughness of the work done and the very apparent economy over hand work, the use of the sand blast is bound to increase when it has the consideration it deserves at the hands of progressive street railway men.—*Electric Railway Review.*

DISEASES OF CAISSON WORKERS

An International Congress, the fourteenth, for Hygiene and Demography, met in Berlin during the last week of September of the present year. Papers were presented upon a wide variety of topics—usually several upon each—all within the scope of the Congress. Some of the subjects treated were as follows: Smoke Nuisance in Large Towns, Hygiene of Public Thoroughfares, The Railway Service, Sewerage and Sewage Purification, Water and Water Purification, Modern Methods of Combating Typhoid Fever, The Campaign Against Yellow Fever, The Malaria Campaign. *Engineering News* has done a valuable service in preparing summaries of the papers presented, these appearing in its issue of October 24. The following relating to The Diseases of Caisson Workers will be of special interest to our readers:

By J. P. Langlois, Professor at the Faculty of Medicine of Paris.

The proposed regulation is itself the conclusion for this report:

(1) Speed of compression uniformly fixed at 4 minutes per atmosphere.

(2) Speed of decompression gradually reduced with the number of atmospheres: 10 minutes per atmosphere below 2 effective atmospheres, 15 minutes between 3 and 2; 20 minutes above 3 atmospheres.

(3) Length of shift varying between 8 and 4 hours, according to the pressure.

(4) Recompression apparatus for work in pressures of above 2 atmospheres.

(5) Room for rest on the working premises and lodging of the workmen in the immediate neighborhood, for work in pressures of above 2.5 atmospheres.

By Dr. Phillip Silberstern.

(1) The caisson workers occupied in highly compressed air are showing a high rate of morbidity, invalidity and mortality.

(2) The typical disease of the caisson and all other workers moving about in compressed air must be defined as aeraemia. It is produced by large quantities of gases of the surrounding atmospheres (chiefly nitrogen) being absorbed in compressed air by the blood and the liquids of the tissues, and being expelled in the shape of small bubbles, when the pressure is rapidly reduced. Besides the aeraemia, but of less importance, are the affections of the tympanic membrane and the

middle ear, caused by a too rapid compression.

(3) Aeraemia can produce sudden, impetuous, often fugitive, sometimes perilous disturbances in many vascular regions. The most noticeable are air embolism in the regions of the pulmonary circulation, paralysis of the dorsal spine due to ischaemia, phenomena of Ménière, pains in the muscles and articulations.

(4) By returning sick caisson workers into compressed air, the heavy injuries of aeraemia can be prevented. This measure must, however, be resorted to immediately, and consequently lodgings for the compressed air workers near the place of work and a recompression chamber equipped with oxygen inhalation apparatus must be provided.

(5) The frequency and gravity of the compressed air diseases peculiar to caisson workers depend in the first place on the height of the pressure and the rapidity of its drop. Aeraemia does not appear if the pressure does not exceed at least twice the amount of the normal atmospheric pressure. Injurious concomitants can considerably increase the danger, as, for instance, tainted air, sudden change of temperature, rapid variations in the air pressure during the work, certain individual factors and long shifts when the pressure is very high.

(6) Sufficiently slow and uniform decompression is the most important measure for the prevention of aeraemia. The minimum period for the drop of pressure ought to be 1½ minutes for every 0.1 atmosphere of pressure.

(7) A permanent service of supervision by physicians independent of the contractors must be established in all cases where work is executed in an air pressure of more than 1.5 atmospheres above normal; the physicians must exclude from the work all persons physically unfit for it and must immediately give notice to the authorities of every case of sickness, so as to enable them to provide in time for the prevention of grave cases of disease, whereby also useful material for the statistics will be collected.

(8) As the compressed air workers are exposed to great but avoidable danger, they must be offered protection by legal measures about similar to those contained in the "caisson bill" of the Netherlands.

By Hermann von Schroetter, Dr. phil. et. med. (Vienna).

Where there is foundation work done under a pressure exceeding 1.5 atmospheres, a recompression chamber (recompression being the specific remedy) of sufficient size must be provided and oxygen (in steel cylinders) must always be kept at disposal to treat sick persons.

In order not to render the existence of the recompression chamber illusory, the workmen ought to be lodged in special barracks erected in close proximity to the building premises.

Great care must also be taken (especially where the soil is impermeable) with regard to the quality of the air in the working chamber, because impurities in the air—carbonic acid (noxious gases, like sulphureted hydrogen, carbonic oxide), high temperature, moisture—favor the appearance of pathologic symptoms during the period of decompression. Consequently, sufficient ventilation by means of cooled compressed air containing but little moisture and supplied at the rate of about 50 cu. m. (1,750 cu. ft.) per head and hour, as well as the use of electric light must be demanded.

In order to prevent physical fatigue, which also favors the appearance of pathologic symptoms, the duration of work in compressed air must be regulated. Up to a pressure of two atmospheres two shifts of 4 hours each are admissible in 24 hours, the time required for compression and decompression being included in these periods. If the pressure amounts to 2 to 3.5 atmospheres the work time, inclusive of time for locking in and locking out, must not be longer than two shifts of 3 hours each per 24 hours. A period of 8 hours at least must be allowed for rest between two shifts. Where work is done in depths of more than 20 m. (65 ft.) lifts ought to be used. The air lock must be easily accessible.

For the above reasons only persons in a perfect state of health (of heart, vessels and lungs) must be employed for work in compressed air; fat, plethoric individuals cannot be admitted.

The air space in the air lock must amount to a minimum of 0.6 cu. m. (210 cu. ft.) per head. During decompression, constant ventilation (simultaneous entrance of fresh compressed air) of the air lock must be provided.

Depth of respiration and acceleration of the blood circulation favor the liberation of the body from gas.

The supply of air must take place at a pres-

sure as constant as possible. Each air supply pipe must be provided with a valve closing automatically when the pressure decreases in the periphery for any reason whatever. Spare pumps must always be kept in readiness.

DEEP MINE SHAFTS AND THE EARTH'S ROTATION

If you go to the Red Jacket shaft in Michigan, says Ralph Pine in a current magazine, whose identity has unfortunately escaped us, you find the most powerful hoisting machinery in the world, huge engines of as much as 8,000 horse-power, which reel and unreel drums of wire cable that wind down a straight mile below the surface. These engines hoist ten-ton cars of ore one mile at the rate of forty miles an hour, or from the bottom to the top of this stupendous hole in the ground in ninety seconds. This is the deepest mining shaft in the world. Apart from this fact, perhaps the most interesting feature of the Red Jacket shaft is in the theory that it is possible to detect the effect of the earth's rotation in a hole as deep as this. No less an authority than President McNair, of the Michigan College of Mines, has explained the belief that nothing dropped in this deepest of mining shafts can ever reach the bottom without colliding with the east side of the shaft.

"This is due to the motion of the earth," said he. "The article dropped, no matter what its shape or size may be, will invariably be found clinging to the east side of the shaft. One day a monkey-wrench was dropped by a miner, but it failed to reach the bottom and was found lodged against the east side of the shaft several hundred feet down. We decided that to make a proper test of the theory it would be worth while to experiment with a small heavy spherical body. So we suspended a marble tied with a thread about twelve feet below the mouth of the shaft. We then burned the thread with a lighted match in order not to disturb the exact fall of the marble. About 500 feet down it brought up against the east side of the shaft. When miners have fallen down the shaft the result has been similar. Their bodies, badly torn, have been found lodged against the east side of the shaft. A carload of rock was dumped down the deepest mining shaft in South Africa, but not a particle of it reached bottom."

TO KEEP COPPER BRIGHT

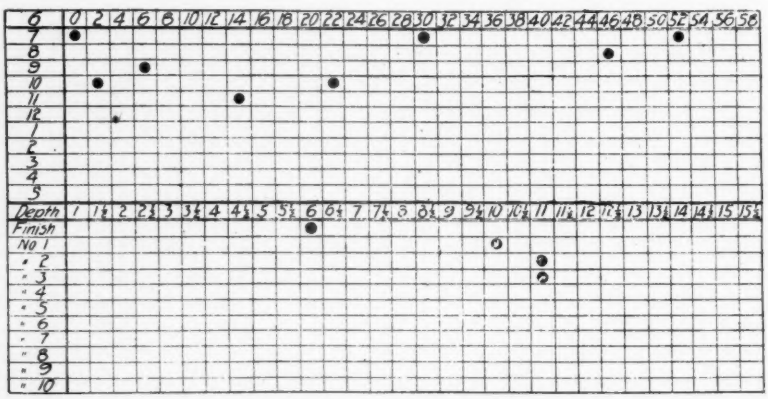
The Brewers' Journal says that the way to keep copper bright is by the use of Zapon varnish, which is a solution of celluloid having an intense odor resembling that of fruit. The copper surface must be thoroughly cleaned and all old varnish removed by scouring with fine sand and water, the final traces of oxide film being removed with a 10 per cent. solution of saccharic acid, leaving the copper bright and shiny. Every trace of the saccharic acid must then be eliminated by washing with water, and the surface afterwards carefully polished with Vienna lime and a little water. Then the surface is ready for varnishing immediately to avoid renewed oxidation. The Zapon varnish is laid on with a pledget of cotton batting by one workman, while another spreads it out evenly with another cotton batting pad, so as to form a very thin coat on the surface of the metal, thicker layers being liable to turn yellow when heated. Any spots not covered with varnish are exposed to oxidation and will show very soon. Care must be taken that the metal be perfectly dry before applying the varnish, even contact with a moist hand being injurious, and the coated surfaces must be left for some time before use, or the deposition of moisture may cause stains. Except for parts in contact with escaping steam, the varnish only needs renewing about once a year, and in the interval no washing is required, the surface being merely wiped over with a cloth. The hands of the workmen applying the varnish can easily be cleaned with acetone.

THE NEW HUM OF INDUSTRY

We speak of the hum of industry: one has never really heard it until he has stood in the growing hull of a 600-foot long steel ship and heard a hundred pneumatic riveters at work. Sign language only is used there. Compressed air is the magician. Even the rivet boys are not allowed to lose time pumping bellows at their forges; a tiny stream of compressed air supplies them with forced draught. If a rivet is countersunk, the rough surplus projecting is not slowly smoothed away by man power and hammers and chisels; a pneumatic tool does it in a few seconds. If an emergency requires a rivet hole which has not been punched, a pneumatic drill does the work as deftly as a cook trims a pie crust.—*Gunter's Magazine.*

A ROCK DRILLER'S RECORD CARD

Engineering-Contracting has devised a daily record card for rock drillers, shown on this page, which should be welcome to both the driller and the contractor or other employer. From the nature of the rock driller's work it is inconvenient to use a pencil, and such a record would often become illegible, so with this card only a small conductor's punch is used. A new card is to be given out to the driller every morning and each card is marked on the back with the date and the designating number or letter of the driller.



A Rock Driller's Record Card.

The upper half of the record on the face of the card has to do entirely with the time of drilling, and the lower half with the depths of the holes as drilled. For the time record the hours are in the vertical column at the left and the even minutes in the horizontal line across the top. The holes drilled are recorded numerically at the left of the lower half of the card, while the depths in halves of a foot are indicated at the top of the lower half. The first hole begun in the day is No. 1, and so on. If a hole was begun the day before and finished in this record a line designated *finish* is provided for this above No. 1.

If we go over the actual record shown on this sample card everything will be clearly understood. We see that the drilling began at 7 o'clock and a hole was finished at 7:30. The depth drilled to finish this hole was 6 feet. Hole No. 1 was begun at 7:52 and finished at 8:46, this No. 1 hole being 10 feet deep. The drilling of No. 2 was begun at 9:06 and finished at 10:02, and it was 11 feet deep. No. 3, begun at 10:22, finished at 11:14, and 11 feet deep. The elapsed time between the finishing of one hole and the beginning of the next was of course occupied in moving and re-setting the drill. By this record the total time was 234 minutes and the total depth 38 feet, which made the rate of drilling 6.16 minutes per foot. The actual drilling time was 192 minutes and the rate 5.05 minutes per foot.

ASSISTING THE SOLUTION OF GOLD IN THE CYANIDE PROCESS BY COMPRESSED AIR

The following suggestion was offered by Mr. Andrew F. Crosse at a recent meeting of the Chemical, Metallurgical and Mining Society of South Africa:

For many years I have been impressed with the idea of using compressed air, produced by a "trompe," for assisting in the solution of gold in the cyanide process. Time forbids my entering into a description of the trompe, but I believe that a trompe was first used in the Pyrenees, during the middle ages, for iron smelting. In this district (Pilgrim's Rest) we have abundance of water power, and I erected a small trompe on my arrival here last October.

More than half the gold here is contained in the slime, so that a high extraction from the latter is absolutely necessary. You are probably acquainted with the Pohlé pump, which is the exact opposite of the trompe, the

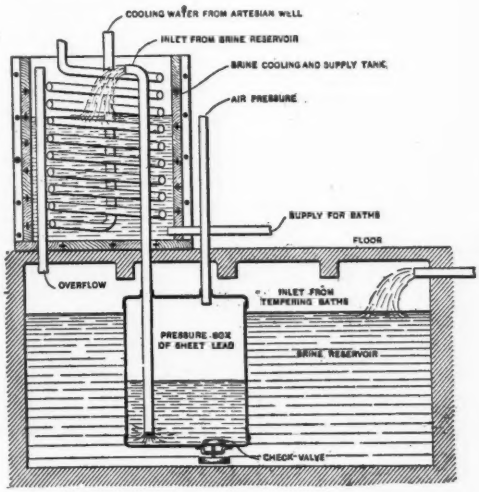
latter being an arrangement by which compressed air is formed, by being sucked down by water and delivered under pressure, whilst the Pohlé pump is an arrangement by which water, or any other liquid, can be lifted, under given conditions, owing to the reduction of its specific gravity, by the admixture of air. I make use of a conical vat, with a vertical pipe in the center of the same, through which the pulp in the vat is lifted by compressed air, supplied by the trompe, 2 ft. above the surface of the liquid; it falls over into an outer tube and is discharged through four pipes, having their orifices tangentically arranged so as to force the pulp into a circular motion. By this means I obtain full aeration and very rapid circulation. The solution of the gold is extremely rapid, and there is no machinery of any kind, it being absolutely automatic.

As this method was so very successful, I applied the same principle, slightly modified, to the sand treatment. The sand must be perfectly clean and free from slime, such as is obtained from the Wilfley concentrator. I have arranged a vat from which the solution drains off into an air-lift pump; this solution is circulated through the sand. After a few hours the sand is full of air bubbles, and a rapid circulation of the liquid is maintained. These air bubbles are formed owing to the cyanide solution being surcharged with air, and they are deposited on the sand, in the same way that a piece of bread, thrown into a glass of champagne, is coated with carbonic acid bubbles. I have obtained 92 per cent. extraction of the gold by this means from 6.2 dwt. tailings in 24 hours, including washing. This result is, I believe, a record.

FOR A COOL SUPPLY OF BRINE

In a valuable article in a recent issue of *Machinery*, describing the manufacture of Swiss files in the United States, an interesting account is given of the arrangements for maintaining a constant supply of cool brine, which is so important an agent in the hardening processes of the establishment. The apparatus is shown diagrammatically in the cut.

The underground reservoir contains a saturated solution of salt and water. This tank is of wood, on which, of course, the brine has no injurious effect. Located within it is a box of sheet lead, with an inwardly opening valve of the same material at the bottom, and an air supply pipe and an outlet pipe, also of lead, entering the top. The latter of these two pipes comes nearly to the bottom of the box. The operator at either of the two hardening furnaces, by pulling a cord, can open a three-way valve, which admits air under pressure at the top of the box. The box being full of brine, which has flowed in through the check-valve at the bottom, the air pressure closes this valve and forces the liquid through the outlet pipe into the cooling and supply tank above. This latter tank is high enough so that the brine flows from it by gravity to the bottom of the tanks at the furnaces. The cooled brine entering at the bottom of these tanks rises and displaces the warmer fluid, which runs through an overflow at the top back to the reservoir again. In the cooling tank is a coil of pipe, through which water flows continuously from an artesian well sunk on the premises. This serves to keep the supply of brine cooled.



COOLING BRINE FOR STEEL HARDENING.

An interesting use of paper is in the making of gas pipes. Manila paper cut in strips, as wide as the length of the pipe to be made, is put into a receiver filled with fused asphalt, and rolled solidly and uniformly around a rod or core of iron until the desired thickness is obtained. After the pipe, thus produced, has been submitted to a heavy pressure, the exterior is covered with sand, and the whole cooled in water. The core is then removed, and the outer surface covered with a waterproof product.

THE COMPRESSED AIR FUNCTION ON THE DIESEL ENGINE

The accompanying cuts give us two sectional views of a 250-h.p. Diesel engine built at Augsburg, Bavaria. The cylinders are 19¾ inches in diameter, the stroke is 29 inches and at 155 revolutions per minute, or 750 feet piston speed, the nominal power is developed. The trunk pistons are 39¼ inches long, giving ample lateral bearing for the angular thrust of the connecting rod. With two fly-wheels 13 feet in diameter and weighing together about 22 tons, the inequality of the turning movement is said not to exceed 1-140. The action is four-cycle, so that the placing of the two cranks together on the same side of the shaft distributes the drive equally.

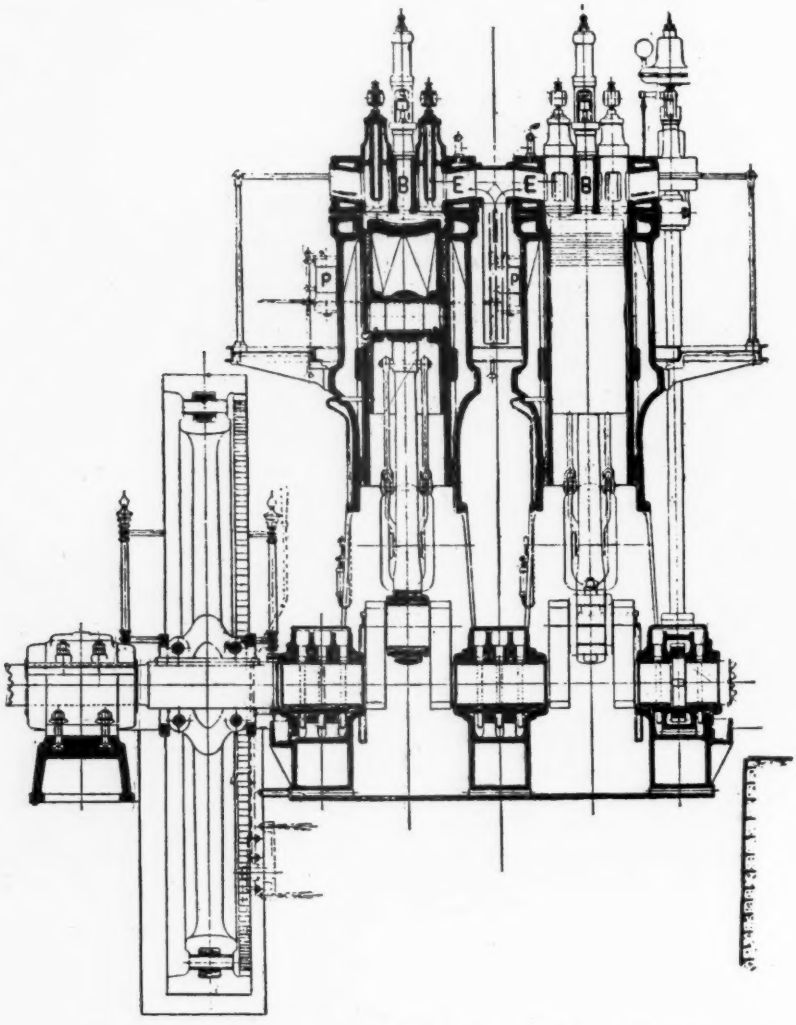


FIG. 1. VERTICAL LONGITUDINAL SECTION OF DIESEL ENGINE.

Considering either cylinder separately, the following is the cycle of operations:

1. The piston moves downward and the cylinder is filled with normal atmospheric air.

2. The piston moves upward, compressing the air and making it very hot.

3. At the instant the piston begins to go down again the charge of liquid fuel for the stroke is injected, mixing with the heated air and being fired, with the result that the pressure is greatly increased by the explosion. This pressure, gradually falling as expansion takes place, constitutes the driving force which continues throughout this downward stroke. The fuel is injected at the beginning of this stroke by means of compressed air, the pressure of which must naturally be higher than that within the cylinder, being actually from 750 to 1,000 pounds.

4. The piston goes up again, driving out the burned and expanded mixture, thus completing the cycle.

Each cylinder has four valves; the starting valve V, for admitting the compressed air; the suction valve E, for the atmospheric air; the fuel valve B, for admitting the liquid fuel into the cylinder; and the valve for discharging the exhaust gas. All the valves are closed by springs and are opened by levers which are actuated by cams S. The cams are all placed upon a common horizontal shaft H, which turns at one-half the speed of the crank shaft and is driven from the latter by helical gears and a vertical intermediate shaft. The levers

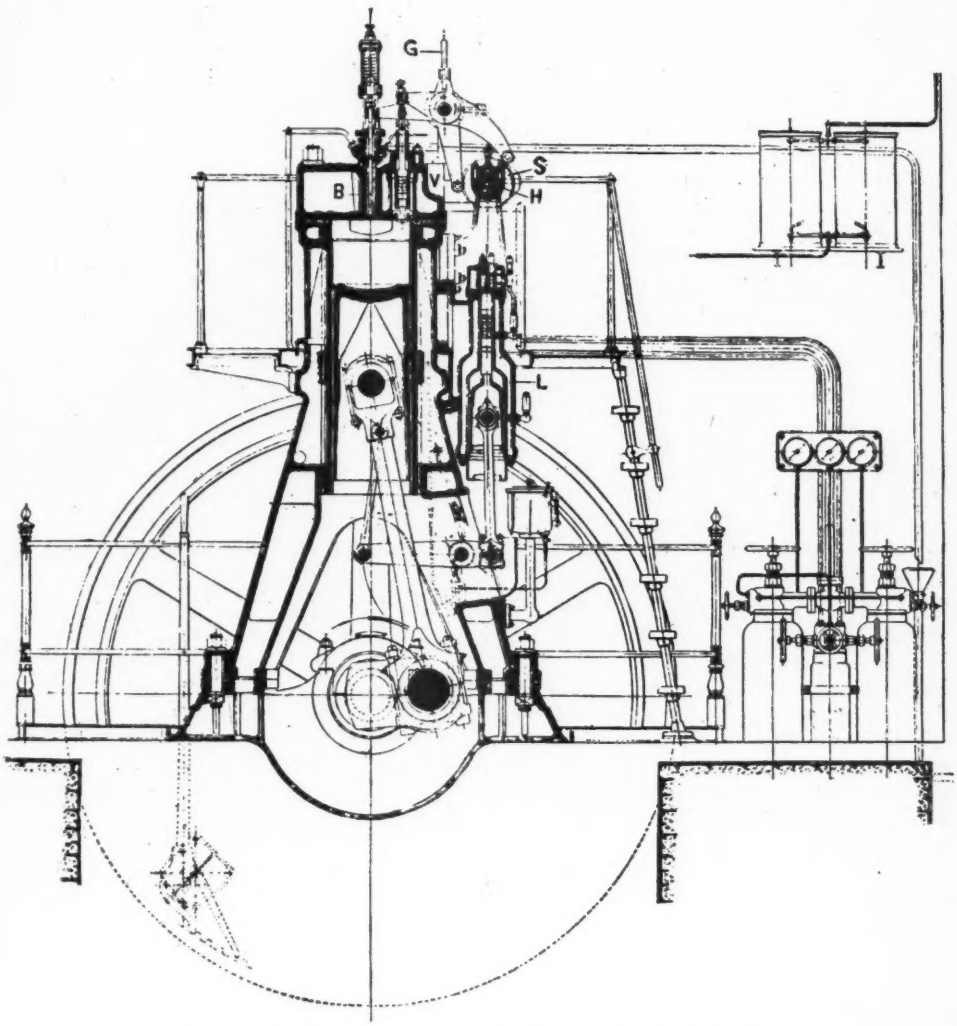


FIG. 2. VERTICAL TRANSVERSE SECTION OF DIESEL ENGINE.

for the starting and the fuel valves, moved by a handle G, are so connected that they cannot both be opened at the same time.

The operation of starting the engine is quite simple. A device is provided for barring the engine over by means of teeth or notches in the fly-wheel, the pistons are thus brought to the upper position and the crank is brought a little past the dead center. Compressed air from the starting reservoir, shown at the lower right hand corner in Fig. 2, the air having a pressure of, say, 50 atmospheres, is admitted to the cylinder by the valve V, and the engine starts, and after two or three revolutions driven by the air pressure it gets up to normal speed. The handle G is at once put over to the running position, closing the starting valve V, and opening the fuel valve B. Compressed air from the air injecting reservoir, which is separate from the starting reservoir, drives the liquid fuel into the cylinder and the regular working of the engine is established, the air injecting operation continuing while the engine is running.

Compressed air for the starting and the injecting reservoirs is provided by two-stage, single-acting compressors attached directly to the engine. Each engine has two of these compressors driven by links attached to the connecting rods. A pressure of 60 atmospheres is maintained constantly in the starting reservoir, and as soon as this pressure is reached it is shut off from the compressor. The air injection reservoir is in constant service when the engine is running, and its pressure is maintained by a continual supply from the compressor. The liquid fuel is delivered to the injection system by a special pump P driven from the cam-shaft H. The valves of this pump are acted upon by the governor, which thereby controls the supply of fuel per stroke and the power developed in consequence, the regulation by this means being as close as may be desired.

The compressor here is a part of the engine just as condenser and air pump were formerly integral parts of each condensing steam engine then built. As later steam engine practice has developed the separate and independent condenser and air pump, so the later and larger Diesel engines, especially of American build, are employing independent air compressors. The machine used is a belt-driven, three-stage compressor, which we may illustrate in a future issue.

COMPRESSED AIR AND HEALTH OF DIVERS AND CAISSON WORKERS

A lecture by Mr. Leonard Hill, F. R. S., given at the recent engineering exhibition held at the exhibition building called Olympia, London, dealt exhaustively with the physiological effects of compressed air on the human body. The following is an abstract of a report in The Engineer, London:

In connection with many important engineering works where men have to carry out operations under compressed air, careful precautions are taken to minimize, as far as possible, injury to the health of the workers, and resident medical officers are employed. Caisson disease is far more frequent in its occurrence, and undoubtedly a great deal of it is due to the carelessness of workers and disregard of rules and regulations. In the case of helmet divers working at considerable depths, it is unusual to find them taking the precaution to decompress slowly, and most of the disease and ill-health of professional divers is due to the too rapid decompression commonly practiced.

The theory of congestion of the blood in the deeper parts of the body induced by variations of atmospheric pressure, is contrary to physical principles, and is quite untenable. Whether it be air or water that uniformly presses upon the body, the tissue fluids transmit the pressure equally, and no mechanical effect is produced. In the modern diving dress the compressed air keeps the water from entering at the cuff. If the dress tears water enters and the body becomes wet, but the man is in no danger, for the air keeps the water out of the helmet. Quite recently the dress of a diver split at a depth of over 130 feet, and it became filled to the level of the helmet. Even at this depth, with a pressure of more than 60 pounds per square inch on the body, no ill results were experienced.

With the exception of a slight ear trouble, none of the symptoms of compressed air sickness occur while the men are under pressure. The ear trouble is due to the inequality of pressure on the two sides of the ear drum. The cause of compressed air sickness is that the nitrogen is dissolved by the blood and the body fluids and, and when the body is decompressed the gas bubbles off in the blood. These bubbles may block up the capillaries locally,

producing, according to location, deafness, vertigo, spinal paralysis, etc. The illness is prevented by making the rate of decompression sufficiently slow, that is, by allowing time for the dissolved nitrogen to escape from the lungs. Lard will dissolve four times as much nitrogen as water, which seems to suggest a point in favor of the employment of lean men as divers.

The lecturer, Mr. Hill, and Mr. M. Greenwood have had a number of interesting personal experiences under high pressures. In a special steel tank Mr. Greenwood was subjected to a pressure of 92 pounds, equivalent to a water pressure of 210 feet. The time of compression was 54 minutes, and of decompression, 137 minutes, the subject experiencing no inconvenience beyond a little temporary pain in the arms.

The precautions to be observed are, first, that at least twenty minutes shall be allowed for decompression for each atmosphere of pressure, a uniform rate of pressure reduction being maintained; and, secondly, that the capillary circulation in every part of the body be maintained by muscular action during the decompression. A record dive was once made of 204 feet (88½ pounds), but the diver died on reaching the surface. Probably the greatest depth an English diver has gone and survived is 189 feet.

The young man who is in perfect health, with powerful heart and deep respiration, can expel the dissolved nitrogen from his lungs far more rapidly than the old, the intemperate, or one who is over-fatigued by excessive labor; and the fat man probably takes up a far larger volume of nitrogen than the thin man. The records of caisson works seem to show that men under twenty to twenty-five years of age escape; that long shifts increase the number of cases; that men who work the air locks, passing material through, and undergoing frequent and short-lasting compression and decompression, are not affected. The longer the shift the more complete the saturation of the body; the higher the pressure the greater the risks and the graver the symptoms. The records show that practically no cases occur with a pressure below 1½ atmospheres, even though the decompression period be made only a minute or two.

Records seem to show that bad ventilation of pressure spaces increases the cases of illness. The medical officer at the Blackwell Tunnel Works held that it is necessary to keep the carbon-dioxide in the air under 0.1 per cent., and this is actually being done now at the Rotherhithe tunnel works at great expense, by the supply of an exceptionally large volume of air to the tunnel face.

We must apparently look to other accompaniments of bad ventilation to discover the sources of the ill effects which result from that condition. Mr. Hill suggests the presence of carbon-monoxide (CO) as a likely cause, and adduces reasons for his opinion. CO is produced in considerable quantities in caisson and tunnel works where flare lights, furnaces and blasting charges are used, or where low-flash oils are employed to lubricate the compressors. It is a fact that the men who worked in the diving bells at the Dover harbor works were free from illness in contrast with caisson workers at the same pressure. The sickness among workers in the New York subaqueous tunnels is considerable, and in the Hudson tunnel works eight men died in six months last year. Mr. Hill suggests that the freedom of the air from CO is possibly one of the causes of the Dover immunity. In connection with the New York tunnel works now in progress "medical locks," or recompression chambers, are used with very satisfactory results, and many serious cases of illness have been beneficially treated by recompression and subsequent slow decompression.

THE ANTHRACITE CENTENNIAL

On the night of February 11, 1808, Judge Jesse Fell, of Wilkesbarre, first demonstrated to his friends and neighbors that anthracite would burn. Pennsylvanians are preparing to fittingly celebrate the centennial of this epochal event. The estimated output of anthracite in Pennsylvania for the year 1907 is 66,500,000 tons, exceeding all previous records. It is peculiarly gratifying to note that two important discoveries of this unique fuel have been made recently. A vein of as yet undetermined but considerable extent has been discovered only a mile north of Gettysburg. It lies only a foot or two below the surface and is said to be eight or nine feet thick. The other discovery spoken of is in the Lehigh field, where a seven-foot vein of the richest fuel has been struck.

ROCK-DRILL ECONOMICS

A paper was read recently before the Chemical, Metallurgical and Mining Society of South Africa by Mr. G. M. Weston, in which he presented various suggestions on the promotion of rock-drill efficiencies. On the question of air pressures he was most emphatic, and he remarked that, under present conditions [speaking, of course, of South African practice.—Ed. C. A.], nothing like reasonable efficiency can be expected from the rock drills. He entered a plea as follows for more data regarding the results obtained by rock drills:

"We have thousands of horse-power applied to boring rock, and yet we are working very much in the dark regarding the true economy of the process. For instance, we know it cannot pay to use a drill-bit after it has been blunted to a certain degree; yet thousands are used twice, and we really know nothing of the amount of loss in boring, say, a foot with blunt steel against a foot with sharp steel. In mechanical engineering the exact angle of the cutting bit is calculated for different work in different material. Conditions are, of course, different in rock boring; but no experiments are made to find the best angle for cutting edges of drill-bits, and what difference a cutting edge of 90 degrees makes to one of 60 degrees in hard and soft rock respectively. Taking into consideration the extra cost of sharpening, providing and removing extra steel, time lost in changing bits, would it not pay to run steels in big machines with a difference of 12 or 15 inches instead of 18 or 24 inches? In boring average reef, what is the best ratio to start with of foot pounds of average per inch length of cutting edge for the blow given by a rock-drill? What is the best relation between mass and velocity for the striking body? For instance, would not a 2½-inch machine drilling at 80 pounds pressure bore faster, even with the same sized bit, than a 3¼-inch machine working at 60 pounds? All these and a host of other questions are, I think, worth answering. Some few experts and some manufacturers may know all about them; but I doubt if they do.

"How much more must a machine that costs $20 per month for maintenance bore than one that costs only $10 per month? Obviously supposing that rock broken costs $1.50 per ton and that a 4-foot hole will break one ton, it has only to break seventeen extra per month, or 6 inches per shift, to pay for itself."

A PECULIAR MINE EXPLOSION

On Thursday, September 12, there occurred at Mine No. 10 of the Union Pacific Coal Co., Rock Springs, Wyo., an explosion of dust, which in its cause and effects is unique in the annals of coal-mining accidents. The accident occurred at about 5 o'clock in the afternoon, when the miners were preparing to leave the mine. About forty of the miners had gathered at the foot of the slope when a trip of empties was started from the top. The coupling between two of the cars had not been properly made, and when the trip reached the head of the slope six of the cars started down the 20 per cent. incline unchecked. By the time they had reached the bottom they had acquired a terrific speed, and collided with a trip of full cars waiting there to be hoisted. Fortunately the men had gotten out of the way of the runaway cars and no one was killed by them, but the impact created a cloud of dust, raised principally from the floor of the gangway, and this dust was ignited by the lamps of the miners. It appears that the mixture of dust and air was not of a character to produce a violent explosion. The results seem to indicate that the quantity of air was below that required to make a highly explosive mixture, and to this must be attributed the escape from death of the forty men injured. There was, however, an instantaneous combustion which produced sufficient heat to burn more or less seriously every man in the immediate vicinity, but none of them so badly that he was not able to walk or crawl out of the manway. The force of the explosion was felt more seriously 200 or 300 feet down the gangway, where a miner standing at the entrance to the mine stable was thrown violently down and sustained a broken arm and other injuries. He was the only man who had to be taken from the mine. One of the peculiar and fortunate effects of the explosion was the partial wrecking of an overcast a short distance east of the slope. This resulted in a short-circuiting of the air current, and as the slope and manway were intakes, large quantities of fresh air, drawn by a powerful fan (which was uninjured) were supplied to the men and carried off the products of combustion, preventing any deaths from suffocation. The air current was so strong that the writer could find no ash or other evidence of the combustion which had taken place.—*Mines and Minerals.*

LARGE INSTALLATIONS OF ELECTRICALLY DRIVEN AIR COMPRESSORS

The following we take from an interesting article by Andrew Floyd Bushnell in *The Engineering and Mining Journal*, November 2:

An authoritative statement from the Amalgamated Copper Company shows that where it costs $100 yearly to produce 1 h. p. by steam, electrical power will cost only $50. [This electric power coming, of course, from water power.—Ed. C. A.] The numerous mines controlled by the Amalgamated Company use approximately 7,000 horse-power in compressing air. Not all these mines have discontinued the use of steam, but they will in time, and when that is done, the Amalgamated Company will save approximately $350,000 per annum.

There are two Ingersoll-Sergeant compressors at the Original mine, which also furnish air for the Gagnon and West Stewart mines. Two 500-h.p. General Electric induction motors, 2,000 volts, are installed. The fly-wheels make 87 revolutions per minute, and the air pressure varies from 80 to 90 pounds per square inch.

The largest air-compressor plant in Butte is at the Neversweat mine. This comprises five large machines. There are two electrically driven Ingersoll-Sergeant compressors. One, 50¼x30¼x60 inches, and 44 revolutions per minute, is driven by three 300-h.p. motors and has been running two and a half years. The other electric compressor is 30¼x60 inches, single stage, and is driven by an 800-h.p. motor; it makes 47 revolutions per minute. This machine has been running five years. The three steam-driven compressors at the Neversweat are duplex, single stage, 30¼x60-inch. The Rarus has two electrical compressors, 39x 24x48-inch. One compressor at the Corra is of the same capacity as those at the Rarus; the other is 23¼x40¼x48-inch. They were all made by the Ingersoll-Sergeant Company.

The most up-to-date plant at Butte is at the Bell mine, where four large Ingersoll-Sergeant compressors are installed. These machines are 38¼x24¼x48-inch and the fly-wheels make 60 revolutions per minute. Except where otherwise stated the compressors of the Amalgamated Copper Company are driven by 600-h. p. General Electric or Westinghouse motors.

The Bell compressor plant, complete, cost $250,000. The building is 100x130 feet, and the foundation consists of 20-foot concrete walls. The compressors are supported by massive cement pillars. The compressor plants of all the large Butte mines are so arranged that should one meet with an accident, the mine affected can be supplied with air from another plant. The steam plants are always kept in running order in case any accident should befall the power plant.

LONDON'S ATMOSPHERIC ECLIPSE

Wednesday, November 20, was a day that will be remembered in London as one of the most detestable this city ever has known. Practically the whole of the day it was dark, dismal night. There was no dawn at the hour when morning light usually drives away the night's gloomy shades; the darkness actually grew denser as the morning came. It was not fog that blackened the sky, although there was some of that about; as one looked overhead it seemed as though all the smoke that had poured out of London chimneys for a month had settled down over the city in a thick black pall. It was a solider, much more substantial darkness than the sort one cuts up into chunks with his carving knife; it was of a sort to be blown to pieces with dynamite.

Another peculiarity of the darkness was that it stayed aloft, and so did not cause so much inconvenience as a thick fog is apt to cause. One could see a fair distance along the street, just as one can see in the night-time. In fact, the streets looked about as they look at night, when the lights are aflame in the shop windows, the offices, and residences. Above it was inky dark; on the street level it was merely the normal night. At the hour when the sun, according to the solar experts at Kensington, was at the meridian, the shop-keepers of Piccadilly, the Strand, Regent street, and all the other business thoroughfares had every light in their establishments burning at full head. The upper floor of the British Museum had to be closed because the darkness made the exhibits on that floor quite invisible. At various points one could read with difficulty electric light signs that were fixed at heights not above fifty feet. Other signs higher up worked in vain, conveying no messages to the people. Such of the illuminated clocks as were fairly close to the ground could be consulted profitably; the rest looked the debilitated anae-

mic little moons, and told the hours to no useful purpose.

There were some weird effects to be seen as one watched the black vapor from his roof or from a lofty window. I saw a great volume of smoke pouring out of a bakery chimney rise in an almost straight line for ten feet or so. But when it came in contact with the overhanging pall, it flattened out into a great black disk, which presently was absorbed into the pall and became a part of its Nubian darkness. It was well along in the afternoon before the vapor began to clear away, the atmosphere first turning from black to sickly green, and then gradually lightening until at length blue sky came into view, with here and there a twinkling star. Our real night was gladly welcomed after the literally awful blackness of our miscalled day.—From wireless dispatch to *New York Times.*

LIQUID AIR IN DERMATOLOGY

In the *Journal of the American Medical Association* of August 3rd Dr. Henry H. Whitehouse gives his personal experiences in the use of liquid air in dermatology. A mild and short exposure of the normal skin to a spray of liquid air produces blanching, followed by a moderate congestion; a longer exposure freezes and anæsthetises the part. In applications by means of a swab of cotton wool the resulting inflammatory swelling varies in degree according to the amount of liquid air used, the pressure applied, and the location and character of the tissues. The pain produced is very slight and rarely lasts long. In pathological conditions liquid air relieves pain after a few applications and lessens discharge and odor; it diminishes tendency to hemorrhage and encourages healthy granulation. It produces very little reactionary effect on scar tissue, hence it is of distinct diagnostic value in epithelioma. Dr. Whitehouse points out that extravagant claims were at first made for liquid air in the treatment of many disorders which may be more conveniently treated by simpler methods, including abscess, bubo, boils, carbuncles, ulcers, and warts. It is unnecessary, also, to resort to liquid air for the production of local anæsthesia. There are, however, many disorders in which better results may be obtained with liquid air than with other remedies, particularly in pigmentary, hairy, and vascular nævi, angiomata, lymphangioma circumscriptum, lupus erythematosus, lupus vulgaris, and epitheliomata. Dr. Whitehouse suggests that the secret of success with liquid air lies in the technique. The cotton swab is applicable to all conditions and with a little experience can be used with great precision. Pine sticks of sufficient length to reach the bottom of a Dewar bulb, and so shaped that the liquid may be applied in any quantity, are bound at the end with absorbent cotton to form a flat, round-pointed, or paddle-shaped pad. The excess of liquid should be shaken off and scabs should be completely removed from all lesions to be treated, a thin layer of gauze intervening between the applicator and all mucous or denuded surfaces, otherwise the scab will freeze fast. The factors governing the effect produced are the degree of saturation of the swab, the accuracy of contact, the amount of pressure exerted, and the duration of the exposure. The success of the treatment depends upon a thorough appreciation of these factors coupled with correct judgment respecting the interval allowed between exposures.

CHEAP WATER POWER IN SWITZERLAND

The following data are given of the cost of developing a water power at Vallorbe, in Switzerland. The height of the fall is 70 meters (229 feet), and 3,000 horse-power is used. The expenditures were divided as follows:

Concession and land.....	$6,000
Dam	4,000
Tunnel, etc.	10,000
Pipe line	6,000
Turbines and sluice-gates....	22,000
Buildings	4,000
Dynamos	60,000
Sundries	8,000
	$120,000

Thus the cost per horse-power was $40. Interest and depreciation at 10 per cent. make $4 per horse-power per annum. These results are exceptionally favorable, even for Switzerland; more usually the cost of installation would average $80 per horse-power, and the annual charges $8.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Established 1896.

W. L. SAUNDERS, - - - - - - Editor
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PUBLISHED BY THE

COMPRESSED AIR MAGAZINE COMPANY

EASTON, PA.

New York Office, Bowling Green Building.
London Office, 114 Queen Victoria Street.

Subscription, including postage, United States and Mexico, $1.00 a year. Canada and abroad, $1.50 a year.. Single copies, 10 cents.

Those who fail to receive papers promptly will please notify us at once.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

Entered as second-class matter at the Easton, Pa., Post Office.

Vol. XIII. JANUARY, 1908. No. 1

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A NEW VOLUME OF HOPES

COMPRESSED AIR, as is most convenient and proper, now and hereafter, is to begin and end its volume with the year. We are hopeful and confident of making the volume now beginning the most notable in the history of this publication. This does not mean that it is to be either the largest or the best, because succeeding volumes should easily surpass it if life and growth continue and only the latest should be really the best. We wish, however, to make a new departure and to get on a more accelerated gait. Heretofore the opportunities of the publication have not been realized and its possible scope is still far from full development. COMPRESSED AIR, the publication, having to do with compressed air, the physical fact, of course has to do also with the compressing and manipulation of it, beginning with it in its most attenuated condition and reaching up — or down, is it? — to its liquid and solid states. Air, rather than compressed air, so called, is what we really deal with, so that we not unnaturally may claim as our constituents and supporters all who have interests in the air itself or in any of the various applications and employments of it. Having to do with the physical transformations of it, as to pressure, temperature and volume, and with all the agencies of these transformations we also are interested in its properties, conditions and uses in either state. The touch of air compressed leads us down into the deepest mines to see it ripping out Earth's treasures, and air uncompressed, free air, the freest air, is also ours for aeronautics; and now that, as it would seem, we are really making some actual successes in the art of flight, who shall have the telling of it if we may not? Also it is in our way to know the air still more intimately, to know about the gases of which it is normally composed and of those which may abnormally adulterate or vitiate it. Practically every article or item in our present issue is true to our general topic, each touching the air in some of its relations and in each of which some of us should be interested. We aim thus to promote the interests and to stimulate the interest of all. In our work we will be glad to have the help and coöperation of all, and there are few whom we can help who cannot also help us. One of the most valuable features of such a publication as ours might be and should be in published correspondence and discussion. Kindly send us your letters

of information, of inquiry, of correction or suggestion, of encouragement or reproof. All of our material must really come to us from outside sources, and the more of it comes from friends, or from those most interested or best informed, the better for all of us.

THEORETICAL AND PRACTICAL MACHINE TESTS

The essential point of difference in the traditional and perpetual contest between the theoretical and the practical, in which the latter is so generally the winner, is apt to be not that the former is wrong in any particular but only that its grasp is not all comprehensive. It does not take into account every detail of function which might help to affect or determine the ultimate result. This is frequently shown in the tests of engines and machines which are made by college professors and those associated, and the reports of which have been apparently the favorite filling for the transactions of the societies, in which are determined the consumption of coal, of water, and sometimes even of oil, with usually nothing beyond that.

These reports of fuel economies are innocent enough in themselves, but when they become the sole evidence relied upon in the selection of apparatus for any purpose they are misleading and cannot alone secure the most efficient and satisfactory service. It happens that in addition to the consumption of fuel *the consumption of engineer* is often an important and many times should be the determining consideration. One line of machines may require much more of skill, of care and watchfulness, of minute precision of adjustment than another, and these things are costly. The consumption of time also when delays occur from wear, breakage or derangement, and to which also one machine may be vastly more liable than another, may out-weigh all the possible savings of coal ten times or a hundred times over. The cost of damaging or destructive accidents, the possibilities of which may inhere in one machine more than in another, may in a minute or an hour wipe out a year's saving at the coal pile. The practical testing of a machine, the testing by continuous, every-day, money earning work, cannot fail to take full account and impartial account of every particular which may assist in determining the ultimate economy of operation, and the practical test, therefore, is the only one finally accepted.

There is a certain air compressor, a pioneer in the larger, more serious and responsible business of air compression, which has held its own phenomenally and is still very much in evidence. It has been built in greater numbers, has held more responsible positions, has done more work, has proved itself more reliable in every-day, all-the-year-round service, as well as for all sorts of emergent, exacting and unusual conditions, than any other in the world. It has been overcrowded, abused, neglected and its good name has been attacked both openly and covertly, but it has kept on its way with wonderful pertinacity. Its vitality, to those who are not familiar with the various episodes of its career, is perhaps its most wonderful characteristic.

And yet the explanation is simple. The machine is fairly efficient in every detail of its working, but above all it is reliable. This reliability is the largest factor and the one given first consideration when ultimate efficiencies are being considered. It has stood the supreme test, the practical test of continuous service satisfactorily. It has made friends continually for itself by its general habit of meeting and satisfying all possible requirements in the line of its work.

We might have what we might call tests of the bodily performance of different animals as compared with the human machine, and according to the function which was given prominence and made the basis of the individual test a hundred different animals would be separately the victors, yet we find no man on earth who would choose the body of any animal in preference to his own for the sake of the single point of excellence. In himself and with his natural equipment he can do more things and do them with possible satisfaction than would be possible in any other way.—*Cassier's Magazine.*

COMPRESSED AIR LEAKAGE

At the recent New York annual meeting of the American Society of Mechanical Engineers a paper on "Power Service in the Foundry," by Mr. A. D. Williams, of Pittsburg, contained the following paragraph, the italics being ours:

"As generally installed, with a central compressing plant, the use of compressed air requires an expensive transmission line and in addition, *it is impossible to avoid leakage in*

the joints. Compressed air leakage does not show, and the pipe lines for this purpose, as usually constructed, are designed to remain tight only long enough to pass the acceptance test. Leakage is a continual drain on the system, and shows up in the amount of coal consumed. Except in the large sizes, air compressors are steam eaters like steam pumps; for this reason the small electric driven air compressor presents numerous advantages, as it consumes no power when out of use, and, if portable, avoids the long pipe line."

This made an opportunity for Mr. Frank Richards, who discussed the matter as follows:

"For line piping for compressed air transmission precisely the same pipes and fittings are used as for steam or water, and it is no more difficult to make joints tight, or to keep them tight, for air than for steam or water. In fact, it is much easier to keep air pipes tight than steam pipes, as the same heating and cooling, and the accompanying expansion and contraction stresses, do not occur.

"It might be well for Mr. Williams to step over to the excavation at West Thirty-third street for the Pennsylvania Terminal. He will find there considerable lengths of compressed air pipes running all around the excavation, with branches reaching in various directions to hoists, pumps and rock drills, and if he can find any leaks there he will do what I have not been able to do.

"At the Phillipsburg shops of the Ingersoll-Rand Company all the power transmission is by either electricity or compressed air. There are some miles of compressed air pipes and various air operated devices are employed, both in the foundry and elsewhere, and the pressure left in the pipes at night is found in them next morning.

"The quarry of the Cleveland Stone Company at North Amherst, Ohio, has nine or ten miles of compressed air pipes, all the machinery of that extensive quarry being air driven, and there the piping is 'bottle-tight.' Air leaks are not discoverable because they are not there. Full pressure is found in the receivers after standing 24 hours.

"In the paragraph under consideration we are further told that 'compressed air pipe lines, as usually constructed, are designed to remain tight only long enough to pass the acceptance test.' The compressed air business, just like the other established lines of manufacture represented by hundreds of members of this society, has grown and has prospered not by the passing of acceptance tests, but by all-the-year-round efficiency and reliability after acceptance.

"In this connection it seems to be permissible, if not imperative, to call attention to a record of compressed air practice which is unique. For supplying the compressed air by whose agency the various tunnel enterprises of Greater New York have been carried so nearly to completion, there have been installed, all of them being still in place, eighty air compressors. The combined free air capacities of these compressors amount to 190,000 cubic feet per minute, which volume would be represented by a cube with a side of 57 feet. They develop an aggregate of 40,000 horsepower.

"These compressors as they were erected were almost immediately put to work and if there was any acceptance test in any case the ceremony was generally omitted. The compressors have worked constantly, most of them day and night and always some on Sundays, at speeds never before recorded and with the responsibilities of life and death upon their maintenance of the working pressures; conditions of unusual difficulty and many of them unforseen and unprovided for have developed; there have been accidents and delays innumerable in the progress of the work; all these we have heard of, but not one word of any shortcomings of these compressors.

"The work of building these tunnels, as is well known, was done under the direction and approval of some of the world's most experienced and responsible engineers and by several different contracting companies but every one of these eighty compressors was built by the same manufacturing company. The acceptance test may be said to have been in the completion of the entire task and the triumphal accomplishment of this is in sight.

"We are told in this same paragraph that 'except in the large sizes, air compressors are steam eaters like steam pumps.' The steam driven air compressor of any size is normally a stationary steam engine with its power applied directly to the work of compression and for steam consumption and power development it is always comparable upon equal terms with the ordinary stationary engine of the same type. It may have a plain slide valve with suitable lap, it may have an adjustable cut-off

or it may be a completely automatic engine with Corliss or equivalent valve gear, and we may in every case expect the same economy in the compressor as in the stationary engine. The ordinary steam pump of any size has clearances large and uncertain; but certainly large, it uses the steam entirely without expansion, so that the pressure at the end of the stroke is as high as the highest; its piston speed is slow. It is comparable only with itself."

MAGNETIC HOISTS

It looks as if the air hoists long used so successfully in American machine shops will be rivalled by hoisting magnets which are coming into great favor in British iron works. Castings weighing two or three tons are lifted by electro-magnets. Much time is saved in comparison with the use of hooks, slings, and other devices, as the mere throwing of a switch energizes the magnet, and the apparatus is able to hold on without any catching and securing devices.—*Exchange.*

But, bless you, the magnet doesn't do the hoisting. It only grabs the load, and it can only grab iron or steel at that, and for that it's very handy, but air or other power has to do the hoisting, the same as always.

THE ACTUAL CAISSON DISEASE FATALITIES IN THE HUDSON RIVER TUNNELS

We are glad to print the following letter addressed to *The Engineer,* London, concerning the mortality among the workers in the Hudson River tunnels caused by working in compressed air. It is of course authoritative and final, and it should be gratifying to all to know that such care has been taken of the lives of the men employed and that the current stories of heavy mortality prove to be so exaggerated and so widely at variance with the facts.

"Sir—I beg to hand you herewith a letter from our chief medical officer in charge of the Hudson and Manhattan tunnels, as also the Pennsylvania tunnels under the North River, with reference to the statement as to death due to caisson disease in your valuable paper of October 18th, and I shall be glad if you are able to publish the facts as herein stated.

"Since I have taken charge of the construction of these various tunnels, on the initiation of the work I took particular care to protect the men in all reasonable ways possible, and selected Dr. Loomis as the best practical medical man I knew on this subject to take charge of the entire force. He has under him on this work four assistants. I have also given the strictest instructions with relation to the acceptance of men for compressed air work, and I am sure that at least 50 per cent. of the labor offered has been rejected for medical or physical reasons by the examining medical officers, and during their occupation medical supervision is very carefully carried out, as well as other means, in the interest of preservation from fatalities and caisson disease.

"CHARLES M. JACOBS, Chief Engineer.

"Hudson Companies, New York,

"November 8th."

"To Mr. Charles M. Jacobs, Chief Engineer:

"Dear Sir—I desire to call your attention to an article appearing in *The Engineer,* London, of October 18th, 1907, entitled 'Compressed Air and Its Influence on Health,' from which the following is an extract: 'It is a fact that the men who worked in the diving bells at the Dover Harbor works were free from illness in contrast with caisson workers at the same pressure. The sickness among workers in the New York subaqueous tunnels is considerable, and in the Hudson tunnel works eight men died in six months last year.'

"Since the resumption of work on the Hudson River tunnels in 1902 I have been in charge of the medical department of that work, as well as that of the North River division of the Pennsylvania tunnels, which comprises the whole of the subaqueous tunnels in connection with the North or Hudson River.

"During that time there has been constructed in round numbers 41,800 linear feet of tunnel under the river itself or its filled-in banks. In this work my records show that there have been examined for work in pressures varying from 15 pounds to 42 pounds over 21,000 men. Of that number there were no deaths from compressed air sickness in the Pennsylvania tunnels—12,000 feet—and but two in the Hudson Companies tunnels.

"This is such a flagrant misstatement of facts that I feel in justice to the work and myself, I cannot allow it to pass without protest.

"I respectfully beg of you, as chief engineer of all the tunnels building under the Hudson

River, otherwise known as the North River, to transmit the above facts to the editor of *The Engineer*, London, for his very kind consideration in the matter. Yours truly,

"A. J. Loomis, M. D.,
"Chief Medical Officer."

QUESTIONS AND ANSWERS

F. C. S., Toledo.—*Q.:* If 150,000 cubic feet of air enter a downcast shaft 16 feet in diameter at a temperature of 55 degrees F., what must be the diameter of the upcast shaft to pass this air at the same velocity when the temperature of the upcast is 105 degrees?

A.: With the pressure constant, as it may be assumed to be in this case, the volumes will be directly as the absolute temperatures. These temperatures being $55+461=516$ and $105+461=566$, and the areas or capacities of the shafts being directly as the squares of their diameters we have the following proportion:

$516:566::16^2:280.8$ and $\sqrt{280.8}=16.75$ feet or 16 feet 9 inches.

J. A., Knowles, Cal.—*Q.:* A two-stage air compressor with the low pressure cylinder 18¼ inch diameter and the high pressure 11¼ inch, with a common stroke of 14 inch, compresses air to 100 pounds, gage; what pressure should be maintained in the receiver between the cylinders?

A.: The receiver or intercooler pressure, and the consequent intake pressure of the high pressure cylinder, in this case is determined by the relative capacities of the two cylinders and remains constant whatever the terminal pressure of the high pressure cylinder. Both cylinders of this compressor being of the piston inlet type, as indicated by the addition of the ¼ inch to the nominal diameter of each to compensate for the displacement of the piston inlet pipe, the effective diameters may be assumed to be 18 and 11 inch respectively. Then the intake pressures (absolute) of the two cylinders will be inversely as the squares of their diameters, always assuming that the intercooler delivers the air to the high pressure cylinder at the original temperature. Then we have: $11^2 : 18^2 :: 14.7 : 39.36$ and $39.36 - 14.7 = 24.66$ gage pressure for the intake of the high pressure cylinder. It is desirable to have the compression ratios in the two cylinders as nearly alike as possible in order to equitably divide the work. In this case the compression ratio in the low pressure cylinder is $14.7 : 39.36 = 0.3734$, and in the high pressure cylinder it is $39.36 : 114.7 = 0.3431$, which is as near as could well be wished. While we are on this compressor it may be worth while to note and compare the power required for single-stage and two-stage compression. We assume a piston speed of 300 feet per minute in each case. The mean pressure per stroke for adiabatically compressing from atmosphere to 100 pounds gage, 14.7 to 114.7, being 41.6 (Richards' Compressed Air), we have $18^2 \times .7854 \times 41.6 \times 300 \div 33{,}000 = 106.24$ horse-power for single-stage compression. For two-stage compression, the compression in the low-pressure cylinder being from atmosphere to 24.66 pounds gage, say 25 pounds—it would really be a little more than that on account of the friction in passing through the intercooler and connecting passages—would be: $18^2 \times .7854 \times 17.01$ (m.e.p.) $\times 300 \div 33{,}000 = 39.35$ horse-power. Then for the high-pressure compression from 24.66 to 100 gage (39.36 to 114.7 absolute) the mean effective unbalanced pressure per stroke being 49.34 the horse-power will be: $11^2 \times .7854 \times 49.34 \times 300 \div 33{,}000 = 42.63$, and $42.63 + 39.35 = 81.98$, say 82, total horse-power for two-stage compression. As we found the horse-power required for single-stage compression to be 106.24 the additional percentage of power thus required would be $106.24 \div 82 = 1.295$, or 29½ per cent. In practice probably a saving of 25 per cent. might be realized by the two-stage compression. The more important advantage really in two-stage compression to pressures approximating 100 pounds is in the avoidance of damaging and dangerous temperatures. The theoretical final temperature attained in compressing by single stage from atmosphere to 100 pounds and from initial temperature of 60 degrees is 485 degrees, while in two-stage compression the highest temperatures possible would be 234 degrees in the low-pressure cylinder and 249 in the high-pressure cylinder, these temperatures all affected and held down to some extent by the water jacketing.

W. M. S., Botson, Tex.—*Q.:* I find in a certain "Pocket Book" the following example and solution:

Example: In a compressed air plant the gage shows a pressure of 80 pounds per square inch; the area of the piston is 20 square inches, and its stroke 10 inches. The pump makes 100 strokes per minute; assuming that there is no

leakage of air past the piston, what will be the volume of air discharged from pump into the mine per minute?

Solution: The volume of air discharged from the pump cylinder per minute $= \frac{20 \times 10 \times 100}{1728} = 11.57$ cubic feet (cylinder pressure). The absolute pressure on the air in the cylinder is $80 + 14.7 = 94.7$ pounds. The absolute pressure on the discharged air is simply the atmospheric pressure (14.7). Hence we write the proportion 14.7 : 94.7 :: 11.57 : and working this out we have $94.7 \times 11.57 \div 14.7 = 74.54$ cubic feet per minute, nearly.

Now, what I do not understand is this: if the piston has an area of 20 square inches and the stroke is 10 inches the piston will displace or compress 200 cubic inches per stroke, and making 100 strokes per minute the total amount of free air handled will be 20,000 cubic inches, or 11.57 cubic feet.; how then can there be any more air delivered into the mine even though the pressure be 80 pounds, and is not the quantity discharged into the mine 11.57 cubic feet, instead of 74.54 cubic feet, and, if not, why not?

A.: There seems to be a little misunderstanding in this case. The cylinder spoken of is not a compressor cylinder, but the cylinder of a steam pump in which compressed air is used to drive the pump instead of steam. The cylinder is filled at each stroke with air at 80 pounds pressure, or 11.57 cubic feet at that pressure, for the 100 strokes, and when this air is discharged into the atmospheric pressure of the mine the volume becomes, after the temperature is equalized, 128,843 cubic inches, or 74.56 cubic feet. Of course when the usual clearance and other losses were allowed for the volume would actually be 25 to 50 per cent. larger than this.

TRADE PUBLICATIONS

Wrought Iron Pipe vs. Steel Pipe, Reading Iron Company, Reading, Pa.; 14 pages, 6x9 inches. This is the sixth edition of a pamphlet first printed in 1906. It makes a strong argument for and cites numerous authorities as to the superior endurance and longevity of wrought iron pipe in competition with modern steel pipe.

Boiler, Ship and Structural Rivets, The Champion Rivet Co., Cleveland, Ohio; 78 pages, 6x9 inches. Reports of elaborate tests are given with various other valuable information concerning "Victor" rivets manufactured by the above firm, and a considerable number of large and excellent half-tones are given showing structures in widest variety in which Victor rivets were used.

Storage Batteries for Portable Service, The Westinghouse Machine Company, Pittsburg, Pa.; 32 pages, 6x9 inches. This publication is devoted to a new line of manufacture of this company. There is no text to distract or weary the reader. The various types of batteries with every detail are shown by excellent half-tones and copious information is furnished entirely in tabulated form.

COMPRESSOR AND DRILL PRACTICE ON THE RAND

The following was written by a special correspondent—name not given—to *The South African Mines.* It contains nothing of information or advice of any value or pertinence to American miners—what do we know of the low pressures, the leakages, the all-round inefficiencies here spoken of?—and it is only reproduced here as giving a realization of the loss in regions supposed to be at least in touch with us and to know not only of our means and methods but also of our rate of working and accomplishment. When will there be a waking up, and who is to do the awakening?

"A series of tests recently made on these fields has demonstrated beyond a doubt that with compressed air at 60 pounds pressure at the rock drill, a good 20 per cent. more work can be done than with only 50 pounds, and that with 70 pounds air pressure the work done by the rock drill is a good 40 per cent. greater. What would have been done with 80 pounds air pressure, such as the American and Australian miner is accustomed to, could not be determined because none of the mines on the Rand carry it underground.

AIR LOSSES.

"The loss due to leaky pipes is admittedly not inconsiderable. The real air loss, however, is not in volume, but in pressure, *i. e.,* friction due to small pipe lines accounts for 90 per cent. of the bad air pressures encountered underground. For instance, there is a 3 pounds loss in pressure due to feeding air to rock drills through 50 feet of one-inch

air hose. Add 50 feet of one-inch air pipe and the total loss in pressure is 7 pounds. The loss in the average drive pipe line is rarely under 10 pounds, and frequently 20 pounds. Deduct all these friction losses from the 70 to 75 pounds pressure in the engine-room, and it is not difficult to see where the air, coal, and money goes.

ICE V. ROCK.

"The rock drill on the Rand not only has to put up with bad air pressures, more often under 50 pounds than over, which is often the fault of the mine management, but also has to contend with a great deal of moisture in the compressed air, due as a rule to faulty construction of the air compressors and failure to provide an air after-cooler, or in lieu of this, large enough air receiver capacity on the surface and sufficient water traps underground. The efficient rock drill underground overcomes this disability, but some makes of drills labor under it badly, in that their exhaust ports are improperly proportioned and the machine designed to drill rock becomes a most efficient ice machine. As the miner does not get credit for the ice thus produced he takes a most violent prejudice to such machines, and quite rightly, because an ice machine is no good for drilling rock.

UNDERGROUND SURPRISES.

"Recently a manager of one of the groups detailed a man to go down the night shift and make a report on the air pressures underground. Quarter-hour readings taken all over the mine during the shift showed something like 40 pounds air pressure. At another mine, of another group, the consulting engineer admitted an underground air pressure of only 55 pounds, the 20 pounds excess in the engine room being accounted for by pipe line friction. The manager of a mine belonging to a third group discovered that by substituting a 2-inch pipe line for a 1¼-inch line, he secured 15 pounds higher pressure at his drills, the machines then doing in one shift what had previously taken two shifts to do. On a mine belonging to a fourth group the "air report" handed in gives the air pressure at 70 to 80 pounds in the engine room, whereas an average of 65 is more correct; underground it is 45 to 50.

DRILL BITS.

"The demand for low costs has brought about the use of a cheaper steel, *i. e.*, instead of using a sixpenny a pound steel, the prevailing grade bought is sold for about a third, and in some cases, a half less. This would not be so bad in itself if proper care was taken in forming and tempering the bits. But in too many cases they are so badly formed as to "rifle" or "fitcher" in the hole, which creates a use for the inevitable 10 pound sledge hammer and "sprains" some of our machine drill costs. In other cases, just as frequently bad tempering leaves the drill bit so soft that it is dull after the first few minutes work, and then proceeds to chew up air at the rate of halfpenny per minute, doing practically nothing. With the mines furnishing the hoped-for 70 to 80 pounds air pressure, and the makers alive to the fact that rock drills and not ice machines are wanted on these fields, it will probably be found desirable to use a higher grade of steel to bear the increased power and do the larger amount of work expected therefrom. Quality, not price, will then be the chief consideration, especially if we temper with temperatures instead of colors. Due to poorly formed and badly tempered drill bits, the average mine on the Rand is compressing at least 25 per cent. more air per shift than necessary. Carrying the argument to its logical conclusion, we find that cheap drill steel and poorly formed and badly tempered bits cost the industry as a whole something like fourpence per ton of rock hoisted more for air power alone than if good drill bits were used. Underground air pipe lines of too small a diameter account for our wasting 20 per cent. of the coal used to compress air for rock drill purposes. If this assumption is correct, it is costing the industry another fourpence a ton more for rock broken by machine drills than it should, due to air lines being too small.

LEAKY PIPES AND BAD AIR PRESSURES.

"To keep 2,200 rock drills supplied with compressed air costs about a half-million sterling, and if only 10 to 15 per cent. is lost through leaky pipes the loss is £50,000 to £75,000 per annum, or 1½d to 2d per ton of rock broken by machines. With 40 to 55 pounds air pressure something like 5,000,000 holes are drilled here, with machines, per annum and cost about £1,300,000 for labor alone. Increasing the pressure at the working faces to 70 pounds would increase the capacity of the machine drills about 40 per cent. or reduce the cost per ton by about 9d. This is what is lost to-day.

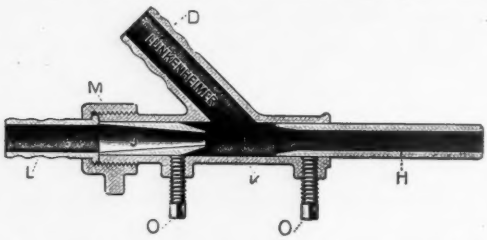
IMPROVED SAND BLAST NOZZLE

We show on this page an improved sand blast nozzle made by the Lunkenheimer Company, Cincinnati. The most troublesome feature of the sand blast apparatus has been the rapid wearing of the outlet tubes. This is said to be overcome in the present device by the special hardness of the metal employed. Attention is called to the internal shape of the

air tube J. The shape here adopted is found to not only give greater force to the impinging particles, but the result is accomplished with a reduced air consumption. The body K, tail piece L and union M are made of a hard, high-grade bronze. The wearing parts, outlet tube H and air tube J, can be readily and cheaply renewed.

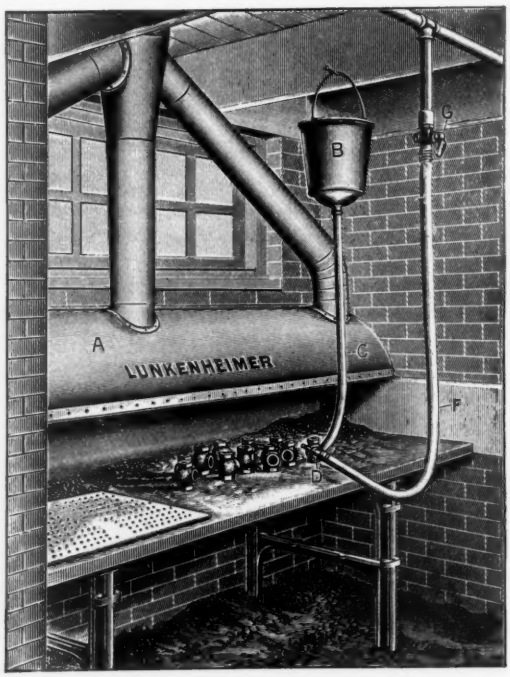
To secure the best results it is recommended that a pressure of from 60 to 100 pounds be carried, the tubes being adjusted to suit the pressure. The higher the pressure the nearer they should be brought together, and they are easily secured by the set-screw O.

It is claimed for the nozzles here shown that from 30 to 50 per cent. more castings can



be cleaned by them than by the means usually employed. The smallest corner can be easily reached, and when the blast is applied to brass castings an effect is produced which resembles wire brushing.

The larger illustration shows a sand blast room in which this nozzle is employed. Here on the bench are a lot of small castings with complicated cores. The room is partitioned off by itself. A hood A is fixed above the bench and to the hood is connected a suction pipe which carries off the sand. It may be gathered in a settling chamber and used over again. A reservoir B for the sand to be used is suspended in a convenient position and a hose C leads to the nozzle, and the sand descends by gravity. A hose F connects with the air supply and a valve G turns it on or off as desired.



SANDBLASTING SMALL CASTINGS.

NOTES

The four deepest mine shafts in the world are in the Lake Superior copper region within a mile of each other. These are the Red Jacket shaft of the Calumet & Hecla Company and shafts Nos. 3, 4 and 5 of the Tamarack Company. The first is vertically 4,920 feet, and the Tamarack No. 5 is a vertical shaft 5,130 feet deep.

The imperial statistical bureau in Berlin has just published the result of a census of the professions, trades and occupations pursued in the empire. The complete list includes 15,016 items. Some of the callings have tens of thousands of followers. In many cases there are only a few. The list illustrates the German love of accuracy and also the capacity of the language for exact titles. One man, for in-

stance, is set down as Forstshutzdienstanwarter, which means candidate for the forest protection service. The climax of title is reached in the somewhat numerous and somewhat humble group who are described as Eisenbahnbetriebstelegrapheninspektionsassistenten. These are the assistant inspectors in the railway telegraph service. One man makes his living by *renting out compressed air.*

Speaking of gas heated core ovens ("gas fired core stoves") Mr. A. R. Bellamy, before the Manchester Association of Engineers, spoke of a novel method of determining when the contents of an oven were quite dry. The difference of temperature between the gases when entering the oven and when leaving is due to the heat given up to the cores plus a constant amount for radiation, etc. When, therefore, the cores are quite dry the difference between the temperature of the gases on entrance and exit would decrease and finally become constant. Two thermometers would, therefore, enable the time to be easily determined when the cores were all dry.

A new and very successful method to prevent infiltration of water in walls and the soil is described by "Elettricita" of November 1. Compressed air is conveyed into a vessel furnished with a mixer containing lime or cement well diluted. To inject the cement, a flat-nosed fire-hose nozzle is employed. The nozzle is applied against the wall or the earth, and gradually moved over all parts. Special attention is given to the arched parts of vaults and points of contact with the soil. The cement thus injected gradually sets, forming a single piece with the main work, increasing its strength and preventing all chance of infiltration.

One of the engineers of the Cleveland water department, who assisted in the construction of the Cleveland water tunnel, believes that he has discovered in compressed air the cure for consumption. He has arrived at this conclusion after watching the effect of compressed air on men at work under it. He declares that one consumptive was completely cured and that many men whom the engineers were afraid to place under compressed air because of weakness, thrived upon it. In the New York tunnel he claims that physicians have also found consumptives improving. A number of practical tests are to be made.

It is said that a bullet fired by a charge sufficient to give it an initial velocity of 1,700 feet a second in dry weather would travel no more than 1,300 feet through moist air.

This is an irresponsible paragraph which cannot possibly be true. The *initial* velocity in either case would be practically the same, as that would be imparted to the bullet before the resistance was begun to be encountered. Definitions would be required as to what was dry air and what moist air. Moist air would be dry air at a higher temperature, and *vice versa.*

The town of Thompson Falls, situated along Clark's Fork River and in proximity to the falls of the stream, is built upon gravel ground. Some years ago one of the early settlers started the sinking of a well on the river bank and was astonished to find a cold wind of some velocity coming up out of the gravel after the well-hole was down about 40 feet. This wind, or "breath from mother earth," was ice-cold; he continued the well to 60 feet depth and secured a large flow of ice-cold, clear water; the cold air continued to flow out of the well, and the well-digger found that he could, by placing a grate at the top of the well, utilize the cold air for refrigerator purposes. Since that time many other wells have been dug and all give the same result. By running a pipe of about one foot in diameter from the side of the wells to the adjoining store and house cellars the buildings are kept delightfully cool during the hottest weather. Perishable foodstuffs are better preserved than when placed in ice refrigerators. In the winter it is necessary to batten the doors and wrap the pipes; also, to thoroughly protect the wells, else the water in the bottom of the wells will freeze into a solid block of ice as a result of the cold air.—*Mining Reporter.*

The annual report of the British Weights and Measures Association records steady progress in the task of defending British weights and measures against the attacks of the advocates of the metric system. The association is supported by representatives of all indus-

At the end of 1904 ten tons of diamonds, valued at $300,000,000, had been taken out of the Kimberley mines. It is difficult to imagine what has become of them all, and, since they are durable and permanent, how the demand for them keeps up. Twelve years ago about twenty million dollars a year was spent for diamonds, and now the expenditure is larger.

It is less than a decade since the first steam turbine was sold in the American market, but there are to-day about 700 in use throughout the country, aggregating a total capacity of approximately 1,000,000 kilowats or about 1,500,000 horse-power. An interesting test was conducted recently by the engineers of the New York Edison Company at the Waterside station near Thirtieth street. The unit under test was a Westinghouse turbine of 10,000 horse-power. It had been sold under a steam consumption guarantee of 15.9 pounds of steam per kilowatt hour, but the test recorded the phenomenally low steam consumption of a shade less than 14.9 pounds per kilowatt hour, the lowest record for steam consumption which has ever been recorded by a stationary steam engine.

Theoretically, a miner working underground requires only 6½ cubic feet of fresh air per minute for respiration and the absorption of moisture and the dilution of carbonic acid gas. This assumes that air after having been breathed is immediately removed without mixing with the surrounding atmosphere, a condition impossible to fulfill. Considering that the permissible vitiation of air by carbonic acid is six parts in 10,000, it will be found necessary to provide 66 cubic feet of air per minute to dilute and carry away the 0.8 cubic feet of carbonic acid produced per hour by one man. Considering the problem in this light, it is evident that, although an average man at work breathes only about 750 cubic inches of air per minute, the amount necessary to carry away the gases given off is the important consideration.

The largest diamond so far known was found at the Premier mine, in the Transvaal, in January, 1905. It weighs 3024.75 karats (9582.4 grains, very nearly one pound six ounces). It is an irregular prolate spheroid about four inches long. It is supposed to be a fragment of a much larger stone.

LATEST U. S. PATENTS

Futl specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissione of Patents, Washington, D. C.

NOVEMBER 5.

869,893. HYDRAULIC ROCK-DRILL. GEORG E. GJUKE, Trelleborg, Sweden.

In a device of the class described, a cylinder, a piston, a fluid pressure chamber on the axial line and to the rear of the cylinder in communication with the rear portion of the cylinder, and means actuated by the piston for drawing atmospheric air into the fluid pressure chamber upon the working stroke of the piston and compressing it therein upon the rearward or back stroke.

869,909. ANEROID BAROMETER. ADOLPH E. KAHN, New York, N. Y.

869,925. PRESSURE-GAGE. DANIEL M. MOORE, Newark, N. J.

869,930. AUTOMATIC AIR-BRAKE APPARATUS AND METHOD. JOHN T. MCINTOSH and JAMES S. MANTON, Chicago, Ill.

869,966. PROCESS FOR COMPRESSING AND PURIFYING AIR. WILLARD O. FELT, New York, N. Y.

870,167. AIR-INSPIRATOR. JOHN HEIMLICH, Port Clinton, Ohio.

870,178. HAMMER-DRILL. ALFRED E. JOHNSON, Denver, Colo.

870,190. ACETYLENE-GAS MACHINE. LOUIS H. MILLER, Campbell, Cal.

870,325. PNEUMATIC RENOVATOR. JFHN S. THURMAN, St. Louis, Mo.

870,523. PNEUMATIC TOOL. OWEN W. THOMAS, St. Paul, Minn.

NOVEMBER 12.

870,546. AIR-DRIER FOR DESICCATING APPARATUS. ERNEST W. COOKE, New York, N. Y.

870,630. MEANS FOR CONTROLLING FLUID-PRESSURE. FRANK E. KINSMAN, Plainfield, N. J.

870,651. FLUID-PRESSURE-OPERATED TOOL. HENRY H. VAUGHAN, Chicago, Ill.

870,659. VALVE FOR PUMPS, COMPRESSORS, AND THE LIKE. HUGO ACKERMANN, Berlin, Germany.

870,806. FLUID-PRESSURE BRAKE. WALTER V. TURNER, Edgewood, Pa.

870,891. AUTOMATIC GAS-CONTROLLER. JOSEPH C. LANDES, Collegeville, Pa.

870,981. VACUUM CLEANING SYSTEM. FRANK J. MATCHETTE and RICHARD RADDATZ, *Milwaukee*, Wis.

871,079. MEANS FOR INCREASING THE AIR-BLAST OF CONVERTERS AND FURNACES. RALPH BAGGALEY, Pittsburg, Pa., CHARLES M. ALLEN, LO LO, Mont., and EDWARD W. LINDQUIST, Chicago, Ill.

871,086. ENGINE. WILLIAM O. DUNTLEY, Chicago, Ill., and GEORGE H. HAYES, Philadelphia, Pa.

NOVEMBER 19.

871,164. AIR-SHIP. AMOS C. ELLSWORTH, Newport, Vt.

871,186. PNEUMATIC EQUALIZER FOR VEHICLES. CHAIM ROSENZWEIG, New York, N. Y.

871,194. HUMIDITY-REDUCING APPARATUS. RICHARD H. THOMAS, Chicago, Ill.

871,209. JET BLOWING APPARATUS. ALRFED COTTON, Newark, N. J.

871,277. PRESSURE-REDUCING VALVE. ANDREW T. JOHNSON, Tonopah, Nev.

871,292. TURBINE COMPRESSOR, PUMP, AND THE LIKE. CHARLES A. PARSONS and ALFRED O. CARNEGIE, Newcastle-upon-Tyne, England.

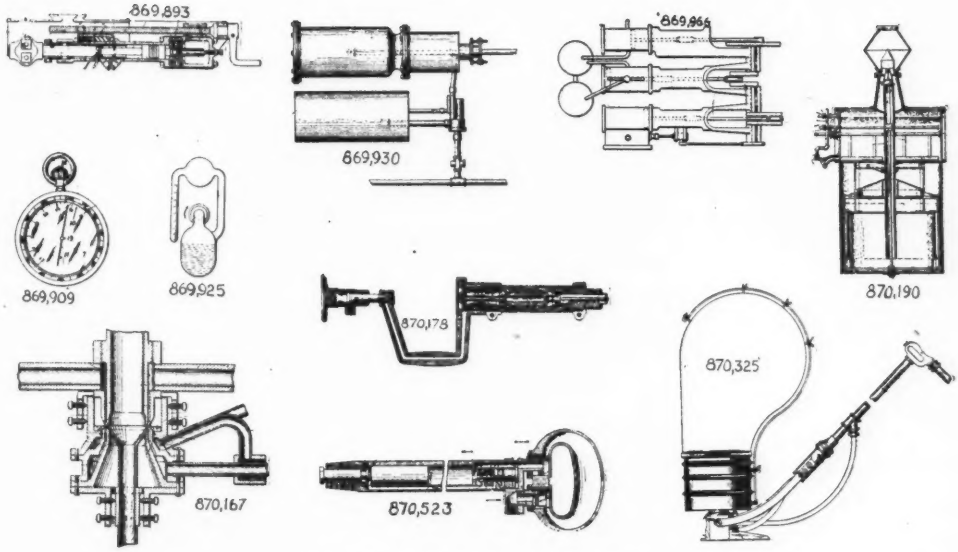
871,350. PERCUSSION-DRILL, &C. BRADFORD H. LOCKE, New York, N. Y.

871,360. ELECTRIC AND PNEUMATIC GOVERNOR. WILLIAM K. RANKIN and THOMAS F. KELLY, Philadelphia, Pa.

871,391. PNEUMATIC GATE. WILLIAM P. ELLIOTT and WILLIAM P. ELLIOTT, JR., La Grange, Ill.

871,508. GAS-ENGINE. JOHN HOULEHAN and WILLIAM C. MAYO, El Paso, Tex.

In an internal combustion engine having a power cylinder provided with an explosion chamber and means for introducing the explosive mixture and ex-



PNEUMATIC PATENTS, NOVEMBER 5.

hausting the burned gases, a compressed air reservoir, means for establishing and cutting off communication between the said reservoir and the explosion chamber of the engine, a movable member forming the rear wall of the explosion chamber, and means for adjusting said movable member to cut off communication between the explosion chamber and the intake and exhaust means.

871,594. ROCK-DRILL. EDWARD N. JONES, Victor, Colo.

871,626. TURBINE AIR-COMPRESSOR. ENOS C. POLLARD, Seattle, Wash.

871,656. HYDROCARBON-BURNER FOR FURNACES. BURT L. WORTHERN, Tucson, Ariz.

871,756. VALVELESS PNEUMATIC TOOL. FREDERICK S. GRAHAM, Philadelphia, Pa.

NOVEMBER 26.

871,816. VISE. JOHN E. OSMER, Chicago, Ill.

871,910. PNEUMATIC THREADING DEVICE FOR SPINNING-MACHINES. FRANK A. BREEZE, Philadelphia, Pa.

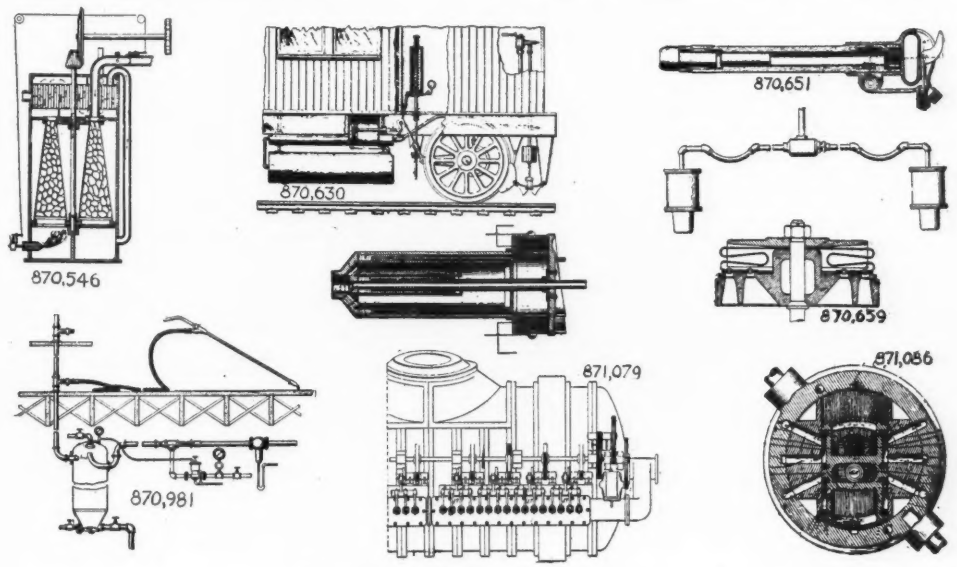
871,926. AIR-PROPELLER FOR FLYING-MACHINES. LOUIS GATHMANN, Washington, D. C.

871,939. PORTABLE PNEUMATIC DRILL. HENRY J. KIMMAN, Cleveland, Ohio.

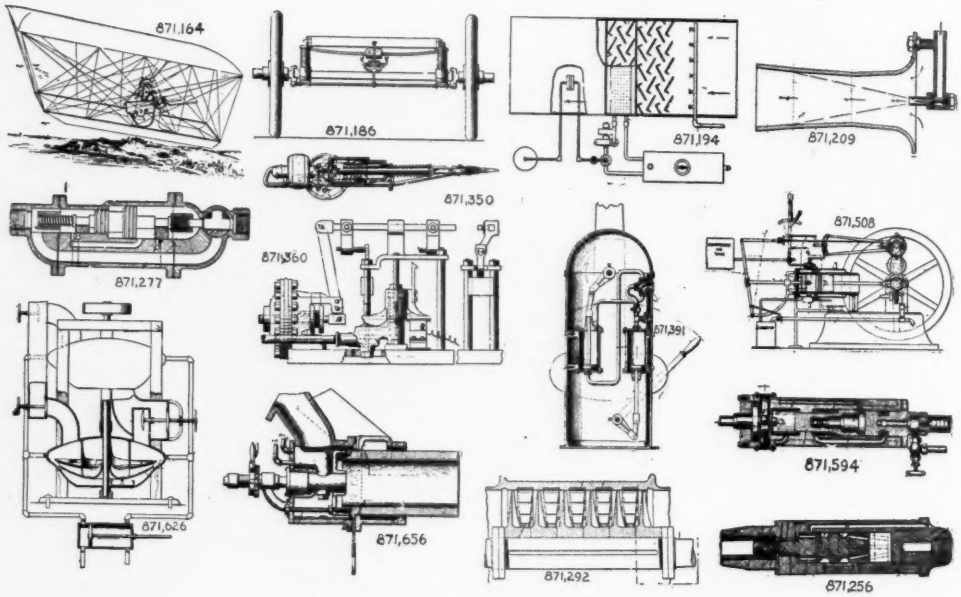
871,973. MULTIPART MOLD FOR PNEUMATIC TIRES. FRIEDRICH VEITH, Veithwerk, near Höchst, Germany.

872,026. DEHYDRATING APPARATUS. FRANK T. STARE, Waukesha, Wis.

In a dehydrating apparatus, the combination with a chamber in which the material to be treated is



PNEUMATIC PATENTS, NOVEMBER 12.



PNEUMATIC PATENTS, NOVEMBER 19.

placed, a condenser and an air drier, of means to maintain a current of air flowing through said chamber, condenser and drier and means to reverse the direction of the current of air through said chamber.

872,043. AIR-PUMP. JOHN C. BECK and JOHN A. BOWYER, Chicago, Ill.

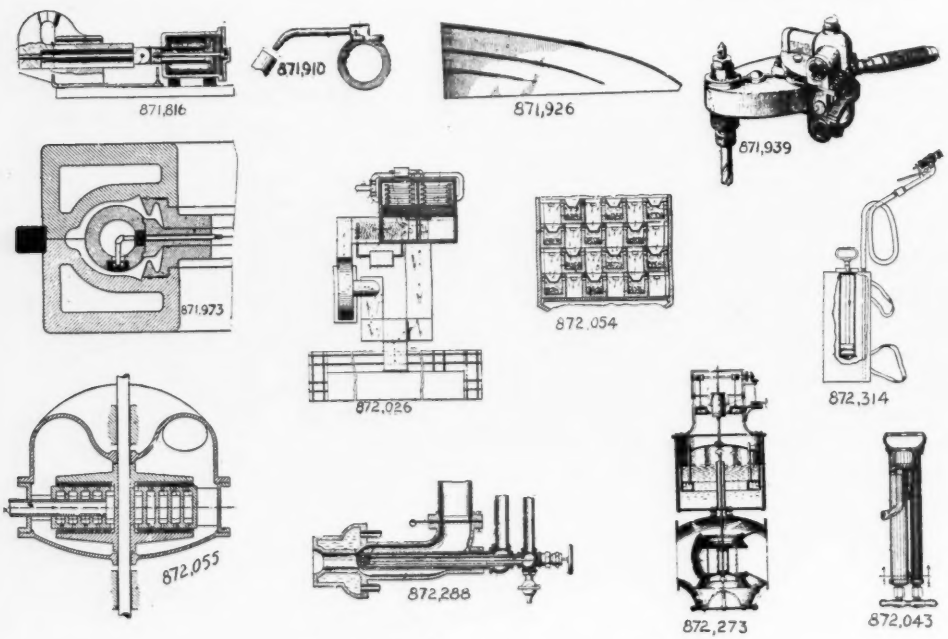
872,054. AIR-DRIER. ERNEST W. COOKE, Waukesha, Wis.

872,055. ELASTIC-FLUID TURBINE. GUSTAF DALEN, Stockholm, Sweden.

872,273. GAS-PRESSURE REGULATOR. ADELARD D. BRASSON, San Francisco, Cal.

872,288. LIQUID-FUEL BURNER. JOHN H. KOONS, Anderson, Ind.

872,314. PIOCoSS OF RoMOVING PAINT AND VASNISH. JOHN M. WILSON, Montclair, N. J.



PNEUMATIC PATENTS, NOVEMBER 26.